UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C. 20460

July 30, 2001

OFFICE OF
THE ADMINISTRATOR
EPA SCIENCE ADVISORY BOARD

Note to the Reader:

The attached draft report is a draft report of the EPA Science Advisory Board (SAB) Advisory Council on Clean Air Compliance Analysis (Council). The draft is still undergoing final internal Council review Once approved as final, the report will be transmitted to the EPA Administrator and will become available to the interested public as a final report.

This draft will be discussed at a public teleconference on August 9, 2001, previously announced in the FEDERAL REGISTER [66 FR 30912-30915: June 8, 2001]. The reader should remember that this is an unapproved working draft and that the document should not be used to represent official EPA or SAB views or advice. Draft documents at this stage of the process often undergo significant revisions before the final version is approved and published.

The SAB is not soliciting comments on the advice contained herein. However, as a courtesy to the EPA Program Office which is the subject of the SAB review, we have asked them to respond to the issues listed below. Consistent with SAB policy on this matter, the SAB is not obligated to address any responses which it receives. Responses are due no later than August 6, 2001.

1. Has the Committee adequately responded to the questions posed in the Charge?
2. Are any statements or responses made in the draft unclear?
3. Are there any technical errors?

For further information or to respond to the questions above, please contact:

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Review of the Draft Analytical Plan for EPA's Second Prospective Analysis - Benefits and Costs of the Clean Air Act 1990-2020: Advisory by a Special Panel of the Advisory Council on Clean Air Compliance Analysis

Draft
July 27, 2001

An insert date

The Honorable Christine Todd Whitman
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Ariel Rios Building, Mail Code 1100
Washington, D.C. 20460

Dear Governor Whitman:

The U.S. EPA Science Advisory Board's Advisory Council for Clean Air Compliance Analysis (Council) met on July 9--10, 2001 to review the Draft Analytical Plan for EPA's Second Prospective Analysis. This activity responds to the Council's charge, as defined in Section 812 of the 1990 Clean Air Act Amendments.

EPA's biennial "812 Analyses" serve to inform environmental decision-making by the Administrator. The Council's advice recommends strategies for improving this benefit-cost analysis. Better analyses will be more useful to the Agency as it decides whether and how to adjust the programs that are implemented to achieve the goals of the Clean Air Act.

Past 812 Analyses have provided measures of costs and benefits overall and benefits disaggregated by title of the Clean Air Act. The statutory mandate for the analysis required retrospective and prospective analysis. The committee believes it is appropriate to focus activities associated with future prospective analyses in ways that will inform realistic policy choices. The Analysis, and the models upon which it relies, should address proposals that are plausible in scope and relevant to decision makers.

The accompanying document details a wide array of changes or enhancements that the Council has recommended to the Agency. For your particular attention, the Council's main recommendations can be distilled into four main points:

1. The 812 analyses are unique. No other agency, to our knowledge, provides as carefully developed national-scope benefit-cost analyses for the regulations it must promulgate. While benefit-cost analyses are now required for all major regulations, the 812 Analysis serves to integrate all regulations for the criteria air pollutants under the Clean Air Act and takes a national and forward-looking perspective. The Agency has an opportunity to assume a leadership role using the 812 process as a methodological laboratory for improving the efficiency of regulations. As a result, this activity can have positive effects for other agencies.

The 812 analyses evolve substantially between rounds, as new research enables methodological enhancements. As part of this evolutionary process, the Council proposes a number of significant refinements. The Agency may find it cannot yet fully implement these changes for the Second Prospective Analysis. If so, the changes should be considered for the Third Prospective Analysis. These proposed refinements concern the treatment and/or use of:

a) benefits to ecosystem services, especially non-market services (beyond just commercially exploited natural resources)

b) the appropriate design and use of computable general equilibrium (CGE) models;
c) evaluating the benefits and costs of regulating hazardous air pollutants;
d) geographical disaggregation of benefits and costs.

2. A disaggregation of both costs and benefits on a title-by-title basis was endorsed in previous Council discussions. Upon further deliberation, we have determined that disaggregation by broad sectors of the economy is more appropriate and defensible. The leading economic model that will likely support the 812 Analysis has numerous sectors, but these could be aggregated into approximately six sectors that are relevant to air pollution. This would preserve an ability to discriminate among different control technologies, yet still allow the initial impacts of regulations to be propagated throughout the economy to reveal the full scope of their overall effects. This would be difficult to do title-by-title because the same control technologies might be used to meet the requirements of more than one title.

3. The Council applauds the Agency's efforts to incorporate uncertainty analyses with respect to both benefits and costs, and especially to consider distinctions between the simple direct costs of regulations and their full social costs.

4. The 812 process requires balancing the advantages of existing practice with the insights from new research. The Agency should take seriously the need to ensure that identified limitations of current activities feed back into basic research that can provide new material for the evolution of successive 812 Analyses. Even for some of the major components of benefits and costs, there are still substantial knowledge gaps that prevent complete characterization. Our review identified several areas where there are significant gaps in the current published research available.

Until a major research effort is launched to develop credible methods to quantify and monetize the effects of marginal changes in air pollution on ecosystem processes, future 812 analyses will continue to be plagued by an embarrassing inability to adequately account for the benefits of the CAAA on ecological service flows. Such benefits probably are currently underestimated by orders of magnitude.

In closing, the Council greatly appreciates the efforts of Agency staff supporting the 812 process to provide a succinct written explanation of its proposed analytical plan in advance of Council deliberations and to cooperate in providing supplementary materials requested by individual Council members.

Sincerely;

Dr. Trudy Cameron, Chair
Advisory Council on Clean Air Compliance Analysis

NOTICE

This report has been written as part of the activities of the Science Advisory Board, of which the Advisory Council on Clean Air Compliance Analysis. Both the Board and the Council are public advisory groups providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Board is structured to provide balanced, expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency and, hence, the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names or commercial products constitute a recommendation for use.

Distribution and Availability: This Science Advisory Board report is provided to the EPA Administrator, senior Agency management, appropriate program staff, interested members of the public, and is posted on the SAB website (www.epa.gov/sab). Information on its availability is also provided in the SAB's monthly newsletter (*Happenings at the Science Advisory Board*). Additional copies and further information are available from the SAB Staff at the following address: US EPA Science Advisory Board (1400A), 1200 Pennsylvania Avenue, NW, US Environmental Protection Agency, Washington, DC 20460.

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Science Advisory Board
Advisory Council on Clean Air Compliance Analysis
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EPA's Second Prospective Analysis*

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1. EXECUTIVE SUMMARY

The Advisory Council for Clean Air Compliance Analysis (Council) identifies four major themes that cut across many of the topics and issues in the Draft Analytical Plan for the Second Prospective Analysis. First, the Council advises the Agency to develop a process that guides the 812 Analysis to inform policy choices faced by decision makers. Practical goals for the 812 Analysis can guide decisions related to the second theme, the choice among alternative models, methods and data. For example, decisions must be made about disaggregation, the role of computable general equilibrium (CGE) economic models, and the selection and updating of air quality models. Third, the Agency needs to convey clearly uncertainties that will always be present in forward looking analyses. The Agency should be diligent in explaining what the models, methods and data can (and cannot) do. Fourth, each new 812 Analysis should be treated as a policy tool and an opportunity to identify research needs. As methods and strategies evolve, it is important to track and explain any important changes in models or assumptions and their consequences for the results. It is important also to identify future research needs and for the Agency to address priority needs to strengthen future analyses.

The Council enthusiastically supports the Agency's efforts to quantify uncertainties in the 812 analyses and recommends that the EPA distinguish three types of uncertainty: unmeasured variability, model uncertainty, and scenario design uncertainty. While uncertainty is rarely desirable, it is important for policy-makers to recognize the fact that it exists. Careful characterization of uncertainties will help focus research on filling critical data gaps.

With respect to the scenarios used in forecasting future expected benefits and costs of the Clean Air Act, the Council gives the following advice on how to use the 812 Analysis to help evaluate alternative policies, subject to the constraints imposed by the limits of available methods and data. The Council advises sector-by-sector disaggregation, rather than title-by-title analysis. Concerning geographic disaggregation, the Council recommends that the EPA decline to disaggregate net benefits by region or by group. The Council reluctantly condones limited and well-caveated regional disaggregation of benefits but emphasizes the potential for significant error in any attempt to disaggregate costs on a regional basis. On the issue of changes in energy policy scenarios, the Council's judgment is that the selection of any specific scenario would be premature and injudicious. Instead, the report should be clear about the future energy assumptions being made and the staff should look for ways to assess the implications of altering those assumptions. Future sensitivity analysis may be appropriate after there is knowledge of the shape of any new energy policy.

In general, the Council's Air Quality Modeling Subcommittee thinks that the stated emissions and air quality modeling objectives are valid. However, the Council recommends the development of evaluation protocols and back-up strategies for emissions and air quality modeling. The AQMS raised strong concerns about proposed modeling approaches, based on information currently available for review. Given the fundamental importance of emissions and air quality modeling as the first step in the overall benefit-cost assessment, the AQMS recommends that the EPA Project Team provide emissions inventory and air quality evaluation results to the AQMS for an interim review before the 812 Analysis is initiated.

Concerning the assessment of health and ecological effects, new data on health outcomes related to pollutant exposures make appropriate the proposed extension of the analyses for the Criteria Pollutants. Improvements are suggested for the treatment of morbidity endpoints and stratospheric ozone. The Council advises the 812 Project Team to work with the National Air Toxics Assessment to select one representative Hazardous Air Pollutant (HAP), for which reasonable amounts of data are available, and to perform a prototype 812 Analysis for this specific pollutant.

Ecological effects modeling still lags far behind health effects. Many improvements are necessary to develop a useful categorization of ecological service flows, and the Council strongly recommends framing any analysis of these flows at the level of a watershed or ecosystem.

For the valuation of the benefits of air pollution control, the Council provides advice on the Agency's criteria for selecting estimates for valuing the health risk changes measured with a count of "statistical lives" saved. In particular, the Council comments on the selection of studies for review, and methods to combine the information from those studies. The formal valuation of ecological benefits remains under-developed. The Council reiterates the need to quantify and monetize air pollution effects upon natural environments, and confirms the continuing importance of two goals: a) comprehensive ecological effects estimates and b) more-effective communication to policy makers about the potential significance of ecological effects that are not quantified.

The process of accounting for the full social costs of air quality regulations continues to be challenging. For direct costs, the Council finds proposed approach appropriate but raises some "minor questions" about enhancements to the approach. However, the Council calls on the Agency to strengthen its plan to capture the broader social costs of air quality regulations. Through relative price changes, policy measures can have substantial general equilibrium consequences for consumers, workers, and investors in a variety of related markets besides just that market most immediately affected by a regulation. The Agency needs to examine closely its strategy for choosing a particular Computable General Equilibrium (CGE) model from the available candidates and must not neglect the potentially substantial increases in the social cost of regulations when other market distortions (such as taxes) are already present. Tax-interaction effects will vary from market to market, but cannot be ignored.

2. INTRODUCTION

2.1. Background

The purpose of this Advisory is to begin the Council's process of providing advice to the Agency in developing the third in a series of statutorily mandated comprehensive analyses of the total costs and total benefits of programs implemented pursuant to the Clean Air Act. Section 812 of the Clean Air Act requires the EPA to periodically assess the effects of the 1990 Clean Air Act Amendments on the "public health, economy and the environment of the United States" and to report the findings and results of the assessments to Congress. Section 812 also established the Advisory Council on Clean Air Compliance Analysis (the Council) and gave it the following mission: "to review the data and methodology used to develop the 812 Study and to advise the EPA Administrator concerning the utility and relevance of the Study." EPA has to-date completed two assessments and received the advice of the Council on them: The Benefits and Costs of the Clean Air Act: 1970 to 1990 (published 1997) and The Benefits and Costs of the Clean Air Act, 1990 to 2010 (published 1999).

In this document, a special panel of the Council is reviewing the June 7, 2001 “Analytical Plan" for the study, more formally titled “Benefits and Costs of the Clean Air Act 1990-2020: Draft Analytical Plan for EPA's Second Prospective Analysis.” In the course of the review of this document, the Council will review the Agency’s major goals, objectives, methodologies, and analytical choices for the Section 812 Study before it is implemented.

In its review of the “analytical plan,” the Council and its panel and subcommittees are guided by the charge questions as identified in the Clean Air Act Amendments of 1990,[1]

[1] Specifically, subsection (g) of CAA §312 (as amended by §812 of the amendments) states: *“(g) The Council shall -- (1) review the data to be used for any analysis required under this section and make recommendations to the Administrator on the use of such data, (2) review the methodology used to analyze such data and make recommendations to the Administrator on the use of such methodology; and (3) prior to issuance of a report required under subsection (d) or (e), review the findings of such report, and make recommendations to the Administrator concerning the validity and utility of such findings.”*

a.) Are the input data used for each component of the analysis sufficiently valid and reliable for the intended analytical purpose?

b) Are the models, and the methodologies they employ, used for each component of the analysis sufficiently valid and reliable for the intended analytical purpose?

c) If the answers to either of the two questions above is negative, what specific alternative assumptions, data or methodologies does the Council recommend the Agency consider using for the second prospective analysis?

2.2. Process for Developing this Advisory

The Council decided to form a special "Panel to Review the Draft Analytical Plan for EPA's Second Prospective Analysis." The panel was composed of Council members and members of the Council's Health and Ecological Effects Subcommittee (HEES) and Air Quality Modeling Subcommittee (AQMS) available to participate in a face-to-face meeting. The special panel held a public planning teleconference on June 22, 2001; the HEES held a public teleconference call on June 25, 2001 to address the proposed methodology for evaluating health and ecological effects; and the AQMS held a public teleconference call on July 2, 2001 to address the proposed methodology for emission inventories and air quality modeling. The special panel held a face-to-face meeting in Washington, DC on July 9-10, 2001.

On June 7, 2001, the Agency provided the Council and its subcommittees with twelve "Key Specific Questions Related to the SAB Council Review Charge for the July 0-10 Review of the Draft Analytical Plan for EPA's Second Prospective Analysis." The Council addresses these questions in the text within the context of discussing the relevant chapters in the Analytical Plan, unless the text indicates that responses are provided in Appendix A.

3. SCENARIO DEVELOPMENT

The proposed refinements in scenario development for the Second Prospective Analysis include the use of an additional projection year (2020), and re-evaluation of the three factors that drive future projections: base year inventory selection, indicators used to forecast growth; and specific individual regulatory programs. These proposals have stimulated a number of comments from the Council.

One set of comments concerns using the 812 Analysis to address policy goals. Another set of comments concerns using the scenarios as a tool for improving the data and methods used in the 812 Analysis.

3.1. Using Scenarios in 812 Prospective Analysis to help Address Policy Goals

a) Scenarios for Title-by-Title Benefit-Cost Analysis. Title-by-title disaggregation is proposed in the Analytical Plan in response to previous advice from the Council giving a "strong recommendation for presenting the benefits as well as the costs of the CAAA by title and, preferably, by provision, in future studies." (Council, 2000, p.4).

The Council recommends that the Agency define the policy objectives served by disaggregation and design an appropriate disaggregation approach that will help the Agency make more informed judgments about policy control measures may meet the requirements of multiple titles making it difficult to determine to which title to attribute costs and benefits.

The Council believes that a useful approach would be to examine regulations sector-by-sector. A desired policy goal would be to know the net benefit of tightening or loosening the NAAQS and the net benefit of cranking down emissions standards for nitrous oxides on stationary sources versus mobile courses. To meet that goal, the broadest sectoral breakdown would be to distinguish regulations on stationary, mobile and area sources. To the extent feasible, it would be desirable to seek finer distinctions-- for example, regulations on electric utilities. Benefits and costs computed by sector can indicate the relative efficiency of controls or other emissions management options aimed at different pollution source categories . For example, in this framework it is possible to consider the net benefits of ozone strategies aimed at reductions in emissions from stationary sources (e.g., nitrous oxide controls on the electric power industry) versus motor vehicle strategies (e.g., enhanced inspection and maintenance programs)?

Disaggregation by broad sectors of the economy is more appropriate, defensible, and useful than title-by-title disaggregation. The 35 sector framework identified in the leading national computable general equilibrium (CGE) economic model could be used to isolate or to define appropriate aggregates for approximately six sectors that are relevant to air pollution. This would preserve an ability to discriminate among different control technologies, yet still allow the initial impacts of regulations to be propagated throughout the economy to reveal the full scope of their overall effects.

For the sectoral analysis to inform regulation more effectively, the Council recommends that key individual regulations be analyzed individually, rather than in groups. The most important regulations to analyze would be those with high costs, whose benefits are uncertain. It would seem especially useful to examine the net benefits of regulations whose primary goal is to reduce ground-level ozone, since these regulations are likely to have modest benefits compared to regulations whose primary goal is to reduce fine particles. When doing this kind of analysis, it will be important to note how some regulations (e.g., those dealing with nitrous oxides and volatile organic compounds in particular) provide benefits in ozone as well as fine particle reductions.

b) Geographic Disaggregation. The Council provides a response to the Agency's question regarding geographic disaggregation in Section 9 of this report within the context of Results Aggregation and Reporting.

c) Alternative Energy Scenarios. The Agency requested that the Council provide advice on whether EPA should model alternative baseline energy policy scenarios to address uncertainty about the scope and implications of the President's energy plan. The Council has reservations about the wisdom of conceptualizing and implementing such scenarios at this time.

It would be difficult to "second guess" the full dimensions of the possible new energy policies from the Administration. Thus, any specific set of scenarios designed to mimic a potential policy would have a chance of being irrelevant.

To address the importance of different energy policies, EPA will need to identify the ways each possible change would influence both the baseline and the policy scenarios. On one level, energy policy will have a direct impact upon emission rates, but this will not be the only effect. One would expect that energy policy changes could also influence intermediate and long term relative prices of energy-related factor inputs and consumption goods. Currently, the Council cannot determine from the information provided how relative prices enter into the EPA's models, if at all. As a result, it is difficult to speculate about the consequences of exploring alternative energy scenarios.

There is an intermediate strategy that would allow some later ex post assessment (i.e., after there is knowledge of the shape of any new energy policy). This strategy would identify the elements of the Agency's plan for the Second Prospective Analysis that would most likely be impacted by energy policy (e.g., coal usage, electricity generating capacity, number and types of gasoline blends, energy prices). The EPA could then develop a plan for a set of specific sensitivity analyses of the results of the Second Prospective Analysis. These simulations would alter the ways in which a subset of these elements vary in the primary scenarios, e.g., retiring all old coal-powered plants and replacing them with new facilities.

d) Scenario Projections to 2030. There is a high level of uncertainty regarding many of the drivers of change for projection over the next 20-30 years (e.g., energy supply and demand, manufacturing process changes, changes in consumer preferences, and technological advances).

For example, the mix of on-road vehicle technologies and the effect of low sulphur diesel fuel usage is too uncertain to extend the analysis to 2030. In addition, the benefits estimates presently focus on the direct public health effects of criteria pollutants. Projections to the year 2030 require the Agency to look more carefully into the much broader potential environmental and ecological impacts of regional, national, and global changes, including climate change, and their relationships to implementation of air programs. Because of the increased public sensitivity to global climate change, it is very likely that significant changes in modes of energy usage will take place in the next ten to twenty years. Unless one can sensibly predict these and other changes, doing the benefit and cost modeling for 2030 is not very useful.

3.2. Improving the Data and Methods Used in the 812 Analysis

a) Comparison and Validation between Old and New Models. The analytical plan provided the following reference points in the First Prospective Analysis: the review of base year inventory, growth forecasting, and regulatory scenarios. This format was very helpful. The Council recommends that the Second Prospective Analysis also provide a component that evaluates, for overlapping years (e.g., 2000 and 2010), how updates in each analyses' set of assumptions, data, and models affects the results for costs and benefits. This addition could help evaluate how data availability and model uncertainties influence the uncertainty in each analysis. Where do these improvements have their greatest effects? Would they cause any change in the judgments made regarding analytical design? This strategy assumes that the Second Prospective Analysis would repeat a subset of the First Prospective Analysis done with these revised data or models, and compare the results.

The Council recognizes that it is not possible to fully replicate, with the proposed refinement, every aspect of the First Prospective Analysis. A strategy is needed to consider how the subset of validation exercises would be selected (e.g., identifying areas where the analytical improvements are expected to have the largest impacts and also, perhaps, the smallest). For each exercise, it will be important to check the intuitive plausibility of any differences, as well as the extent of the change. To do this effectively requires a specific design that identifies the interactions between the base year emissions inventory, the intermediate effects data, the models, and the particular scenario that will be considered for this consistency check. What the Council envisions is comparable to the assessment that the Stanford Energy Modeling Forum undertakes for major energy models used to evaluate specific policy objectives. (See the special issue of The Energy Journal entitled "Costs of the Kyoto Protocol" (1999) for an example of the results of one such evaluation).

b) Key Observable Intermediate Variables. It is important to undertake a systematic documentation of how policy outcomes predicted by the Agency's analyses are translated into changes that can be evaluated within economic models and thereby affect both benefit and cost estimation. Has consideration been given to isolating a set of "observable variables," primarily physical and economic measures (such as exposures or elasticities) that are intermediate variables in the computations of benefits or costs and are also likely to differ across the scenarios with and without the CAAA? For example, comparisons might be made of the projected work days lost and included in the morbidity estimates, as compared to days lost to illness in total.

3.3. General Methodological Considerations for all Scenarios

For whatever scenarios EPA may choose to implement, the Council suggests that the Agency make the assumptions underlying the scenarios explicit. To help put the scenarios in perspective for Congress and other interested parties, the Council recommends that for each scenario EPA present a clear and succinct schematic of Titles and how each of them affects emissions of all of the key chemicals. The Agency should then present separate associated diagrams illustrating how each proposed scenario would affect treatment of emission reductions associated with each title. This kind of presentation would help illuminate how the proposed scenarios are being used to investigate how to improve the efficiency of the policies (in the sense of maximizing their net benefits).

4. PROPOSED APPROACH TO EMISSIONS ESTIMATION AND AIR QUALITY MODELING

4.1. Introduction: Recommendation for an Emissions and Air Quality Modeling Protocol

In general, the AQMS thinks that the stated emissions and air quality modeling objectives are valid. The document provides some useful information about the particular emissions inventories to be used and the modeling platform under consideration. However, given the central role of the emissions inventory and the air quality models, it is important that the overall modeling plan (i.e., protocol) be not only provided in the Second Prospective Analysis, but also be presented in draft form to the AQMS for review before the detailed emissions and air quality modeling begins.

The protocol should clearly outline the basic modeling objectives (e.g., level of chemical, spatial and temporal detail needed and level of certainty/accuracy required), key assumptions, selection of specific model components, evaluation steps, back-up strategy if evaluation shows models do not meet objectives, how the models will be implemented in the 812 study and communication plan (e.g., specific way the modeling results will be presented). The Council recommends, as a starting task and first priority in this context, the development of a detailed Modeling Protocol.

For emissions, it will be especially important to:

a) Describe the emission projection methods used and outline how the projections methods relate to changes in energy scenarios and other important driving factors;

b) identify and justify the selection of emission modeling components used for as well as the selection of emission models (for mobile, stationary area, and biogenic emissions

c) describe models used as preprocessors (for chemical speciation, spatial and temporal allocation;

d) outline differences in base years selected for the inventories and how these relate to the selection of the years of meteorology which is used in developing various aspects of the emissions and, along with the emissions, are key inputs for the air quality modeling.; and

e) discuss steps in evaluation of the data including general data quality checking procedures used to catch errors in processing and techniques such as comparison with other emissions data to insure that the emissions are properly depicting current and future conditions.

For air quality models, it will be important to:

a) explicitly identify and discuss the individual air quality modeling tasks to be undertaken;

b) identify the pollutants (criteria and HAPs) to be modeled, and the general framework of the modeling effort;

c) identify (and point to documentation for) all the models and relevant databases (for either model input development or model performance evaluation) that will be considered for the study;

d) provide a detailed timeline with relevant milestones and alternative pathways for attaining the study objectives;

e) specify procedures for both operational and diagnostic model evaluation and for checking the quality of observational data used in comparing the models with observations;

f) establish and justify quality objectives and specific criteria for accepting or rejecting models and databases; and

g) describe and justify the procedures used for selecting modeling study attributes (domain boundaries, horizontal resolutions(s), number and thickness of layers in the vertical direction, etc.).

For both the emissions and air quality models, it will be important to:

a) outline (and justify the selection of) the specific procedures to be used for sensitivity and uncertainty analyses of both the emissions and the air quality (transport/transformation) models; and

b) Describe how modeling results will be presented in the report and how the results will be prepared for use in other steps in the benefit-cost assessment.

The AQMS would like to underscore the need for consistent modeling protocols within EPA.

4.2. Emissions Estimation

Specific guidance is discussed next:

a) Scenarios. As described in section 3.3 of this document, the Council recommends that the EPA present a clear and succinct schematic of Titles and how they each affect emissions of all of the key chemicals. The Council also recommends that the Agency develop a plan for a set of specific sensitivity analyses of the results of the Second Prospective Analysis that are most relevant to energy policy. The Council recommends that sensitivity analyses be done regarding the implications of using more fossil fuel, as might be the case under proposed energy policies, than is assumed in the energy baseline scenario. Along the same lines, the Council recommends considering sensitivity analyses that reflect any different fuel choices, or economies in the transportation sector, that might evolve in the near future. In addition, the relationships between growth, energy demand, location of new power plants and types of fuels and emissions associated with these new facilities needs to be properly taken into account. In particular, power and associated emissions may be produced in one state to accommodate growth and increased energy demand in another state. And for smaller states, growth projection by state may not be appropriate.

b) Stationary Sources. The issues of energy scenarios and growth have a direct bearing on how major point sources are treated, both now and in the future. A careful review of emissions is needed to make sure that no significant sources have been overlooked or double counted.

c) Mobile Sources. The AQMS thinks that it is very important to the credibility and accuracy of the Second Prospective Analysis that the model MOBILE6 be used to estimate the volatile organic compounds and nitrous oxide emissions from on-road mobile sources. The improvements in estimating the actual emissions are substantial and are critical to the purposes of the Second Prospective Analysis, namely assessing the cost and the benefits of control requirements and of possible additional emission reduction requirements. Proper treatment of vehicle miles traveled and the assumed contributions from cold starts will be essential when characterizing current emissions and future reductions.

d) Uncertainties, Consistency, and Evaluation. Comparison of modeled and observed trends is possible and should be conducted (i.e., as is outlined under the uncertainty analysis comments in Section 8 of this document). These comparisons can help identify problems with the emissions and with the modeling approaches. In addition, ongoing regional studies should either be consistent with the 812 Analysis, or careful documentation and assessment of the differences are needed.

4.3. Air Quality Modeling

a) General Comments. The plan states that "EPA plans to employ well-established, peer-reviewed models to generate predicted concentrations for each of the pollutant categories analyzed in the first prospective analysis". This intention, however, seems to be contradicted by what follows in Chapter 5 of the Plan.

REMSAD Version 6, the proposed modeling platform for dealing with multipollutant analyses, is still under development and has yet to be evaluated for applications of the type required for the 812 Analysis. The AQMS has strongly encouraged using a single platform in the prospective studies. However, we are concerned about choosing a platform on the basis of its simplicity and computational efficiency, but applying it to tasks not envisioned or accommodated in its original design. While it may turn out to be reasonable to use REMSAD Version 6, further evaluation of this model is needed, along with documentation of performance to assure the precision of the estimates.

REMSAD was developed to deal with long-term analysis of linear, or approximately linear, problems of aerosols, non-reactive or linearly decaying air toxics, and deposition. The simplified treatment of both atmospheric chemistry (in its most recent versions) and transport was not aimed at assessing problems of tropospheric ozone or of related secondary photochemical pollutants that can be air toxics.

There is nothing fundamentally wrong with using a simplified model for an analysis of the type considered in the Plan. In fact, the simplest model possible, provided it fully satisfies the quality objectives criteria of the intended analysis, should be used for this application. The problem for the current 812 study is that such criteria are not clearly defined in the Plan. In the development of a Modeling Protocol, these criteria should be established at the beginning to reflect the needs of the overall study and should be used for the scientifically defensible selection of the appropriate air quality model.

For the 812 study, there is the danger that the model can be accepted on the basis of low but acceptable accuracy. This could happen especially if the needs of the study require "directional" estimates such as concentration ratios, rather than accurate "single-point" values but not to be sufficiently precise to produce directionally correct estimates. This will be a potential problem, especially considering the character of current ozone control strategies.

Finally, the proposed "linear rollback" approach proposed for sulfur dioxide, carbon monoxide, and nitrous oxides is reasonable, especially for addressing some issues of local hotspots or subgrid variability that cannot be dealt with in the REMSAD framework. However, it is essential to delineate how the proposed analysis will ensure consistency (or resolution of potential inconsistencies) between the REMSAD estimates and the linear rollback calculations.

While the AQMS has advocated moving to a single modeling platform, there is always some concern about too great a reliance on a single air quality model, especially when the chosen model has not been thoroughly scrutinized by the scientific community. REMSAD may not be the optimal model to use. Another model that ought to have been considered is CAMx. But we sympathize fully with EPA's need to conserve resources, and the AQMS will need to learn more about REMSAD version 6 before passing a final judgment on its use in the 812 Analysis. To this end, the AQMS requests the opportunity to review the results of the model evaluation planned for demonstrating the applicability of REMSAD to ozone and fine particulate matter assessments

The Council's detailed responses to the Agency's Key Specific Questions 9, 10, and 11 concerning REMSAD can be found in Appendix A.

b) Usefulness of Other Air Quality Modeling Efforts. EPA should be strongly encouraged to take into account the outcomes and ongoing developments of other efforts both at EPA and at various regional modeling centers. Indeed, there is currently a tremendous amount of activity that can provide useful supplementary information for the activities in the proposed Plan.

For example, there are modeling efforts such as the current National Air Toxics Assessment (NATA) with the 1996 National Toxics Inventory (NTI), as well as various on-going National Exposure Research Laboratory (NERL) studies that utilize variants of the CMAQ model to assess air toxics. For example, a version of CMAQ that includes an ability to model atrazine has been used by NERL to model the period from May through July of 1995, at 36-km resolution, over the eastern US. Results are being evaluated against wet deposition data for atrazine over the Great Lakes area. Another version of CMAQ that includes mercury chemistry, is now being tested by NERL over the eastern US at 36-km resolution. Various modeling groups are currently using data from field studies in attempts to validate alternative versions of aerosol dynamics modules (including the MARS-A module, to be incorporated in REMSAD) within CMAQ, MAQSIP, and other platforms.

c) PM Modeling Evaluation Requirements. The Council's AQMS cannot determine from the draft Analytical Plan the adequacy of methods proposed for PM Modeling, For particulate matter assessment, the AQMS requests to see the preliminary modeling results by component of PM 2.5 and PM 10, in order to judge whether the performance of the emission inventory and modeling systems is adequate to make the required cost and benefit assessments. This information could be provided as part of the REMSAD model evaluation exercise results that the AQMS has already requested for review.

The PM components that the Council's AQMS envisions the Agency modeling are sulfate, ammonium, nitrate, organic carbon, black (or elemental) carbon, and crustal material. With the improvements that have been attempted in crustal material emission estimates, it is important to see whether the ambient concentration estimates that are produced are now more realistic. It is also important to see whether the estimates of primary and secondary organic carbonaceous components of particulate matter match what is actually found from field studies.

The data available will not allow prediction of future PM component concentrations by multiplying the concentration for the base period by a ratio, where that ratio is constructed by dividing the modeled future concentration of the component by the concentration of the component modeled for the base period. However, there are adequate data to check the performance of the model for each component for most areas of the country. (CAN THE AQMS PROVIDE THESE REFERENCES NOW?) The AQMS can suggest sources of information on PM composition which would be adequate for determining how well the inventory plus modeling procedures are representing reality in the base case. This component-by-component analysis is essential to providing an adequate basis for even a qualitative uncertainty analysis for particulate matter in the Second Prospective analysis.

This concern over PM is related to the treatment of health benefits. The health-response threshold issue for PM is not settled because the use of ambient concentrations instead of personal exposure can mask the presence of a threshold. The Council is glad to see that EPA plans to assume no threshold but also plans to conduct a sensitivity analysis to gauge the impact of varying threshold levels.

d) Ozone Modeling Issues. The current blueprint does not explicitly indicate how emissions of biogenic organic compounds will be estimated. There is a new version of the biogenic emissions model (BEIS version 3) that is apparently in a testing phase. The EPA webpage says "It is anticipated that a version of BEIS3 suitable for testing in CMAQ will be ready by January 2000." At this point, it is not clear what will be the differences between Version 2.3 (the current release) and Version 3 or how long it is expected to take before the model will be ready for use in applications like the next prospective analysis. The AQMS suggests that the 812 Project Team provide justification for proceeding with Version 2.3 and outline the differences between this and the newer version. The AQMS would like to review this justification prior to the development of the emissions inventories for the assessment. Given that there is better incorporation of the chemistry of isoprene in REMSAD 6, it is very desirable to improve the estimates of the amount of biogenic compounds that go into the model.

As a result of the suit by the American Trucking Associations vs. Browner (99-1426), the Council recommends that the Agency's analysis address the issue of the potential beneficial effects of tropospheric ozone in reducing ultraviolet-B exposure. It would seem that, given the relatively lower concentrations of ozone even at the higher pressures in the troposphere, [WHAT?] would not make large contributions to the column ozone values. It would then be possible to estimate the total column ozone and apply the same valuation to total column ozone instead of just the stratospheric ozone [LAST TWO SENTENCES UNCLEAR.. "valuation" not economic valuation]

In terms of other health effects, there has been relatively little new work on ozone alone. Certainly the literature needs to be carefully reviewed. The results of Thurston and Ito (2001, in Press) could alter the current characterization of ozone exposure/response relationships if their study is better able to account for meteorological effects. There is a need to reanalyze existing studies for complex interactions of meteorological variables and ozone in terms of their joint effects on health.

e) Toxics Assessment Concerns. The Council's recommendation to carry out a detailed assessment for benzene raises one air quality modeling issue. It is important to question whether the sort of national modeling that is being performed for ozone and particulate matter (PM) assessments is appropriate for benzene. A detailed benefit-cost assessment for benzene control was published in the Journal of the Air Pollution Control Association (now the Journal of the Air and Waste Management Association (PLEASE PROVIDE CITATION) that included exposure during refueling of private automobiles. Since this remains one of the major sources of individual exposure to benzene in areas without Stage II vapor recovery, any assessment that does not recognize this pathway of exposure would be lacking key information about the costs and benefits of the Clean Air Act.

5. PROPOSED APPROACH TO ESTIMATION OF HUMAN HEALTH AND ECOLOGICAL EFFECTS

This chapter amalgamates the Council's comments on Chapters 6 and 7 of the Analytical Plan. This discussion focuses on the problems of identifying the magnitudes of the physical effects of air pollution: predominantly mortality or morbidity in the case of human health effects, and harm to ecosystem functions or services in the case of ecological effects. The next chapter will address the problem of valuing (monetizing) these effects for use in benefit-cost analyses.

5.1 Health Effects

The proposed extension of the analyses for the Criteria Pollutants that is summarized in Exhibit 6-1 of the Analytical Plan is appropriate, considering the newly available data on additional health outcomes related to pollutant exposures cited below.

a) Particulate Matter (PM) and PM Mortality Threshold. The choice of the Krewski et al. (2000) specification as the primary model for predicting PM mortality is reasonable. However, the text on p. 6-5 of the Blueprint should note that this specification extended the analysis to 63 U.S. cities (from the original fifty cities in the Pope et al. (1995) study) and used the mean annual PM 2.5 concentration rather than the median.

The text of the section on PM should be expanded to reflect some recent relevant research reports. These include:

1) The report by Laden et al. on the follow-up study of the six-cities cohort (Laden et al, 2001 FULL CITATION NEEDED).

2) The paper by Künzli et al. on the justification for relying on the cohort mortality studies for the best estimates of PM-related premature mortality (Künzli et al. 2001 FULL CITATION NEEDED).

3) Research reporting significant PM-related infant mortality to supplement the previous paper by Woodruff et al. (1997). These include an eight-city study (in the U.S.) by Kaiser, Künzli, and Schwartz (2001 NEED FULL CITATIONS). One, by Ha et al. (ISEE-134 NEED FULL CITATIONS) describes PM10-related mortality in Seoul, Korea. Two others describe PM10-related reductions in birthweight, which provide coherence support for premature mortality. Bobak (ISEE-209 NEED FULL CITATION) provides data for the Czech Republic, and Wojtyniak et al. (ISEE-331 NEED FULL CITATION) provide data for Poland.

4) The discussion of a lack of evidence for a PM-mortality threshold is appropriate.

New research sheds light on benefits that may be associated with EPA's upcoming National Air Quality and Standards (NAAQS) review of a possible PM10-2.5 standard. At this year's International Society for Environmental Epidemiologists (ISEE) meeting [VERIFY…E can also stand for Economics or Ethics], the paper by Pope et al (ISEE-205 NEED FULL CITATION) describing a follow-up analysis of the American Cancer Society (ACS) cohort in 51 U.S. cities for 16 years of mortality experience will report significant associations between PM 2.5 and both cardiopulmonary and lung cancer mortality. There were no associations of mortality with the coarse thoracic mass (PM10-2.5). For the PM-related mortality estimates for the 812 Analysis , it appears adequate to stay with the PM 2.5 concentration response. There is not sufficient basis in the literature at this time for a separate (and additive) PM10-2.5 concentration response for mortality. However, for pulmonary morbidity, PM10-2.5 can be an important risk factor.

The Krewski et al. (2000) re-analysis of the Pope et al. (1995) study of PM 2.5-associated mortality, using the American Cancer Society (ACS) data, is significant in that it essentially confirms the original findings. The rationale for selection of a specific concentration/response (C-R) coefficient for the Second Prospective Analysis needs to be discussed. The proposal to switch to the mean measure of PM 2.5, rather than the median, makes good sense. Are there specific properties of the candidate analyses, such as the use of a greater number of potential confounders or the range of statistical issues considered, that have guided the selection of C-R coefficients for the primary analysis in the Second Prospective study? Also, it does not seem necessary to include so many alternative estimates. Other than the mean/median issue, the coefficients can be directly compared to see how much difference they would make. It does not seem necessary to calculate all the benefits again in order to assess how much difference the alternative results would make. The Samet et al. daily time series results and the Dockery et al. (1993) (or the Krewski et al., 2000) reanalysis six-cities prospective results would bound any of the results with the ACS data because the daily time series results show a much lower PM mortality effect and the six-cities prospective results show a much higher PM mortality effect.

There is a pressing need to complete research that validates the use of a concentration/response function that is based upon PM 2.5 alone. This research needs to determine whether the concentration-response function is more robust for toxic constituents (individual or multiple) or sub-size fractions of the PM 2.5 mass.

b) Ozone. The text should discuss the findings of Thurston and Ito (in press, 2001) and incorporate any plausible damage function for mortality based on ozone. These authors have reported that the estimate of the O3-mortality effect increases in size and statistical significance when nonlinearity and interaction effects are incorporated into the model's weather specification. EPA needs to assess whether this paper helps to address the uncertainties about potential confounding between ozone and PM 2.5 that led to the dropping of the earlier meta-analysis for ozone mortality.

c) Chronic Asthma and other Morbidity Endpoints. The Analytical Plan neglects asthma-related conditions for each of the NAAQS that could be supported by the Air Quality Criteria documents and other scientific literature (Lebowitz, 1996). There is currently a disconnect between what is said in Chapter 6 of the Analytical Plan and what is included in the tables in Appendix C, probably due to recent changes in plans.

The Agency should be aware that there are various other quantitative estimates in the literature, in addition to those provided in Appendix C. (Lebowitz, unpublished ms.) There are important differences in coefficients when one compares the conclusions from different studies for the same endpoint related to the same pollutant. There is good quantitative data from non-North American studies (and some older US studies as well), but these studies have not been acknowledged in the Analytical Plan. (Lebowitz, unpublished ms.)

d) Health Effects Associated with Stratospheric Ozone Depletion. It is essential to make sure that the agency has the most up-to-date information for the variables and relationships that constitute the input values to the AHEF Model. It is important that this information be presented to the AQMS and HEES for review before the analysis begins.

The Council has several questions concerning the process of updating the Title VI (stratospheric ozone) analysis, in particular, the Benefits Estimation Approach described in Appendix B. The following comments pertain to the Steps identified on pages B-4 through B-7.

1) Is "no further ozone depletion" a valid boundary condition? Some studies indicate that this is reasonable, and it is supported by projections of United Nations Program on Ozone Depletion.

2) What basis is the Agency using to forecast that ozone depletion will decline over the next half century? What uncertainties will be examined in the analysis?

3) Are any activities planned to check the performance of the AHEF model against current or previously collected data on stratospheric ozone or UVB, or precursor levels?

4) How does the Agency adjust for confounding sources of skin cancer? The American Trucking Associations lawsuit against the Agency may make it necessary to respond to the question of possible beneficial effects of tropospheric

ozone in reduce UVB exposure. Does the Agency intend also to look at the effects of UVB on commercially exploited natural resources (such as crops) or on non-market ecosystem assets (including both plant and animal species)?

5) Analysis of the benefits of Title VI necessarily requires a very distant time horizon, such as the year 2165 proposed in the Draft Analytical Plan. Projections this far in the future will necessarily be highly uncertain because of the need to consider climate change and other factors that may influence stratospheric ozone concentrations, and changes in living styles, health care, and other factors that may influence human susceptibility to changes in UV-B radiation. The Council suggests EPA consider the most appropriate time horizon and note the relevant sources of uncertainty.

e) Hazardous Air Pollutants including Mercury. The Panel was asked to address the question, "Does the Council concur with EPA's assessment that currently available methods do not support a defensible quantitative characterization of health risks and benefits valuation for the cancer, non-cancer and ecological effects of air toxics?"

The draft analytical plan is largely silent on the topic of air toxics, other than the statement "EPA will undertake no quantification of health benefits associated with exposure to air toxics." Public perception is that HAPs represent an important health risk, but calculations for the Retrospective Analysis indicated that the benefits from further control of HAPs were likely to be small.

The Second Prospective Analysis will provide an opportunity to place the problem in perspective. To do this, the Council suggests that the Agency consider selecting one representative air toxic contaminant for which reasonable amounts of data are available and perform an 812 Analysis for this specific contaminant as a prototype. The recently published NATA report provides data prior to 1996 on the priority HAPs substances, including benzene. At the present time, benzene provides an example of a "data rich" air toxic contaminant. The degree to which additional information might be available in time for the current prospective analysis should be evaluated. There is substantial literature on the health effects of benzene, and there have been extensive reviews published, although the dose-response information is much less developed than for any of the criteria pollutants. There is also a great deal of ambient concentration data on a national basis. Benzene thus appears to be the best candidate for a prototypical HAP analysis, but others might be considered by the Agency. For example, some of the metal air toxics (e.g., lead, arsenic, and cadmium) are probably better indicators of health effects than benzene, and they are more like PM and other chemicals regulated through the National Ambient Air Quality Standards process.

An 812 analysis using the available benzene data would: 1) identify limitations and gaps in the data base; 2) provide an estimate of the uncertainties in the analyses and perhaps provide a reasonable lower bound on potential health benefits from control; and 3) provide a scientific basis for deciding whether there is merit in pursuing a greater ability to assess the benefits of air toxics.

Another issue concerning air toxics is their potential role in ozone depletion. The extent to which benefits of HAP control might be derived from this ancillary role could be evaluated along with the benefits from reducing other ozone-depleting substances.

5.2. Ecological Effects

The Panel's comments address the Agency's Key Specific Question Number 8, "Does the Council have specific suggestions for improving the coverage of ecological effects endpoints, or specific research citations that might be of use in characterizing ecological effects of air pollutants?"

Chapter 7 and the associated chapters that address ecological issues accommodate many of the concerns raised by the Council's review of the First Prospective Study (EPA, Science Advisory Board, 1999, 2000 and 2000), and the progression of the Agency toward a greater commitment to the sciences of ecology and natural resources is encouraging. There remains concern for the approach to evaluating the benefits and costs of air quality. The Council concludes that many improvements are still necessary and these are highlighted below.

The main issues concern development of a useful categorization of ecological service flows and initiating valuation of these flows at the level of a watershed or ecosystem. Currently, it is likely that only a small percentage of the value of ecological service flows is being quantified, because information and algorithms are not currently available to generate damage functions for most ecological processes at the ecosystem or watershed level. The Council endorses the Agency's suggestion that an initial effort to capture the ecosystem level benefits derived from ecological service flows is appropriate. The Council feels that simple transfers from the erroneous Constanza et al. Nature (May 1997) paper should be avoided. Ecological service flows are best captured at the ecosystem or watershed level. At the present time reliable estimates of benefits from comprehensive ecosystem studies do not exist.

As the literature continues to develop, the Agency should sustain a strong effort to bring non-market ecosystem benefits into the mainstream of benefits calculation. Underlying the 812 Project Team's limited capacity to quantify ecological service flows is the relatively small base of information available about the effects of marginal changes in air pollution on ecosystems. Until a major research effort is funded to develop such an information base and generate appropriate damage functions at the ecosystem or watershed level, future 812 Analyses will probably continue to drastically underestimate the benefits of the CAAA by orders of magnitude. The Council strongly recommends that the Agency plan and implement a concerted research strategy to address this deficiency. A parallel and probably equally massive effort will be needed to develop methods to monetize changes in ecological service flows. These research efforts should be conducted in parallel, with considerable intellectual interchange. The SAB might be able to provide useful input into the planning and review of this research program.

The Council is emphatic in its recommendation that the Agency embrace an ecosystem-level approach to the valuation of benefits from nonmarket ecological service flows that will complement its existing more traditional valuation of commercially exploited natural resources. HAMMITT--THIS CALLS FOR CITATIONS; CAN OTHERS PROVIDE? The growing literature in the ecological sciences community that addresses economics, in combination with the growing literature in economics that addresses environmental valuation, needs to be "brought to the table" in air quality benefits assessment.

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6. ECONOMIC VALUATION OF HEALTH AND ECOLOGICAL EFFECTS

Like the Draft Analytical Plan, this report distinguishes the issue of physical measurement of the health and ecological effects of air pollution from the problem of valuing (or monetizing) these effects for a benefit-cost analysis. Chapter 8 of the Draft Analytical Plan addresses the problem of economic valuation. The following subsections report the Council's reactions to these proposals, first for the valuation of health effects, and then for the valuation of ecological effects.

6.1. Valuation of Health Effects

The "value of a statistical life" (VSL) has been an important parameter in previous benefit-cost analyses. Whereas the value of one individual human life might ethically be viewed as infinite, most environmental regulations lead to marginal differences in the probability of death, albeit for large numbers of people. A regulation that saves one statistical life might be one that reduces the probability of death in a specified time period. Some monetization of this "statistical life" is necessary for achieving dollar-denominated measures of the benefits from this reduction in mortality risk.

The Draft Analytical Plan calls for valuing mortality risk by selecting a set of appropriate VSL estimates from multiple studies, calculating the average estimated VSL, then adjusting this average to account for lags between exposure and death, future increases in real income, and age of the affected population. The Council has the following comments and suggestions related to the proposals in the Draft Analytical Plan.

a) Selection and Combination of Studies. The council commends EPA for its thoughtful and extensive review of the empirical literature on VSL. As described in Appendix D, EPA examined 89 VSL studies. The Council agrees with EPA that no single study is definitive, and that some of the 89 studies provide little or no information relevant to valuing risks of air-pollution-related health effects in the US. Hence, the relevant question concerns which studies provide useful information, and how best to combine the information from those studies.

It is appropriate to conduct a new literature review for the VSL values because there have been many new studies published since early 1990's. However, the updated review does not (and cannot) solve the issue of the applicability of these estimates to the valuation of incremental mortality due to air pollution, because the literature does not provide the answers to these questions yet. The literature is still predominantly providing estimates of VSL for accidental deaths, and there is still very little information about how age or health status might affect the VSL.

EPA proposes a set of screening criteria for VSL estimates, and calculates average VSLs from the set of estimates that satisfy these criteria. The Council has concerns about both aspects of this procedure: choice of screening criteria and the process for averaging of study results.

The inventory of studies reported in the Analytical Plan uses two sets of selection criteria. The first set is intended to rule out studies that do not estimate the desired measure. For the most part these rejections are appropriate. We are looking for estimates of willingness to pay (WTP) for a person's own fatal risk reduction in the current time period. The exclusion criteria listed in the second through fifth bullets on pages D-2 and D-3 of Appendix D are appropriate for screening out inappropriate studies. The Johannesson and Johansson (1997) results should also be eliminated here because they are estimates of value now for risk reduction much later in life. That is not the measure of VSL that EPA should be looking for, for this analysis. Labor market studies using actuarial (total) mortality data, rather than on-the-job fatality data, should also be eliminated in the first round. This is unacceptable study design. There is one specific question on this issue, however: Exhibit 7 claims that Gerking et al. (1988) used actuarial data. This was a CV study using perceived on-the-job risk. The Council doubts that actuarial data were used. It is not clear that pilot studies should necessarily be eliminated because there is not a standardized definition of what a pilot study is. Some authors might use that term while others do not even though the studies are similar in their design and execution.

But many of the screening criteria in the list starting on page D-6 can be challenged. For example, several of the criteria require EPA to draw an inherently arbitrary bright line when studies differ on some continuous attribute (e.g., sample size (criterion #7), baseline risk (criterion #9)). Other criteria are arguable (e.g., the extent to which non-US studies should be included (criterion #6); EPA initially imposes this criterion then relaxes it to include all OECD estimates).

It is also premature to rule out all the consumer market studies, solely because they are lower-bound measures. They should be presented, at least for comparison purposes, because they provide a revealed preference approach that is different from the labor market studies. Even as lower bounds, they can help provide some assessment of the credibility of the other findings.

It is appropriate to limit the selection to one set of results for a given data set, but care must be taken in determining which one of a set of results to select. Results reported in a second publication should not be automatically ruled out as the "best" choice. There may have been improvements in the analysis that make the second set of results a better choice for EPA's purposes. This needs to be evaluated on a case-by-case basis. There is also the issue of different authors analyzing essentially the same data, such as BLS data for comparable years. It is not clear what to do about this.

It is difficult to evaluate a set of selection criteria by observing the selections that result, but it seems like the selection criteria applied to the 60 VSL estimates that emerge from the first selection process are too stringent. Only 16 of the estimates survive, and these include only 9 of the 26 estimates used as the basis of the previous VSL estimates EPA was using. The basic goals of the selection criteria are not clear. Is the objective to find a few studies that provide the very best-suited results for this analysis, or to eliminate just those that are not well suited? There is some argument for leaning toward the latter criterion and to be very cautious about eliminating studies that have passed the first hurdle of using accepted methods to estimate the value that EPA wants to know. It makes sense to drop working papers and very small sample pilot tests, and perhaps very atypical subgroup studies, but other than that, most of the estimates should be retained and further evaluated and compared.

The review would be easier to digest if the review process were presented separately for labor market and stated preference studies. These are very different estimation methods that face different kinds of challenges. For example, the average risk level in the sample population may be a relevant issue for the labor market studies, but for state preference studies, a better indicator would be the magnitudes of the risk increments presented in the survey for respondents to evaluate. However, these should not be selection criteria in either case, but rather factors to be used when comparing results across studies as is done in Exhibit 6.

The Council offers some observations concerning the selection criteria relevant to the labor market studies:

1) Controls for non fatal risk. This criterion identifies a clear conceptual failure in some of the studies, because of the problem of omitted-variables bias in the fatal risk coefficients due to potential correlation of fatal risks with omitted non-fatal risks. Thirty-five studies fail to control for non-fatal risk, but a rough estimate of the resulting bias in VSL due to this oversight, indicated in Exhibit 8, is only about 20% and is not statistically significant. There should be enough studies reporting results with and without controlling for non-fatal risks to assess whether this is a real problem or not.

2) Sample size is generally not an issue for labor market VSL studies (unless they are based on survey data), but non-representative samples may be a problem. Few, if any, of the studies are nationally representative. Blue collar jobs held by men are over-represented in these studies. It is hard to say where to draw the line. The study of police wages may be an example of a too-specialized subgroup. Also, it looks as though there are problems with the measure of risk used in that study.

3) The fact that a paper has reported VSL estimates only in footnotes or tangentially should not be deemed a sufficient cause to eliminate those estimates if the study's methods are appropriate for measuring VSL. Unless the analysis is constrained in some way that distorts the VSL estimates, there does not seem to be any reason to eliminate the estimates just because they are not the primary focus of the paper.

Concerning some of the selection criteria for stated preference studies, the Council makes the following observations:

1) Risk reduction clearly defined. The authors need to explain better the application of this criterion to specific studies. It is listed as a problem for only two studies: Gerking et al. and Low and McPeters. The Council understands the latter to have been a wage risk study, and thus is unsure how this applies. Based on the notes in Exhibit 2, it sounds like the risk measure was not appropriately defined as risk per individual for a wage-risk analysis. This should have caused elimination in the first round. Gerking et al. is a survey study concerning the risk of fatal accidents on the job. It is not clear that this risk reduction was significantly less clearly defined than in the other survey studies in the list.

2) Plausible payment obligations. This does not appear to be a problem.

3) Sample size greater than 200. This has some appeal, but the cut-off point is arbitrary. The necessary sample size varies depending on the elicitation method used. Single referendum style questions typically need more than 200 observations. Open-ended questions may get by with fewer. EPA may pose some unnecessary problems for itself with this criterion, because it eliminates Viscusi et al. (1991), the study used as the basis for the chronic bronchitis value. Their sample size was 195, but the study was well-designed and provides very useful information not available elsewhere. It should not be dropped because of the sample size.

4) Sample representative of the U.S. population. Few, if any, of these studies have samples that are statistically representative of the U.S. population. It would be preferable to

favor a general population sample over samples drawn from very atypical subgroups, such as college students or police officers. Studies of very atypical subgroups should perhaps be dropped, but all general population studies should be included.

After identifying 16 OECD estimates that satisfy the (revised) selection criteria, EPA combines these estimates by fitting a parametric form to the marginal distribution of these 16 individual point estimates and then calculating the mean. In order to adjust for differences in the value of currency, non-US estimates are converted to dollars at the PPP rate for the year in which the data were collected (or published), and all estimates are converted to 2001 dollars using the CPI. Thus, no adjustment is made for differences in income, baseline risk, or other factors that may influence VSL (the inflation adjustment makes implicit assumptions about the income elasticity and growth of income relative to cost-of-living).

The Council suggests that the EPA consider using regression-based meta-analysis as an alternative approach. Meta-analysis can be used to estimate a functional relationship between estimated VSL and a variety of methodological and empirical factors that differentiate studies (e.g., Liu et al., 1997; Mrozek and Taylor, in press). The resulting function can then be used to forecast the estimated VSL for the methodological and empirical context relevant to the Second Prospective study. In principle, meta-analysis has two potential advantages: results would be less sensitive to inherently arbitrary decisions about which studies to include (since all relevant studies would be included, and each study's influence would depend on how consistent its results are with other included studies).

At a minimum, it will be useful for EPA to examine existing meta-analyses so that broader use is made of the information in studies that EPA is currently rejecting. With time and resources EPA could add to these efforts by developing its own meta-analysis. This recommendation depends in part on the quality of existing meta-analyses.

In addition, the Council recommends some further screening of the VSL studies based on contingent valuation methods. The Council suggests that any contingent valuation studies included provide evidence that the estimated WTP is sensitive to the magnitude of the stated risk reduction. A finding of statistically significant differences in WTP for different size risk changes suggests that subjects are responding to the specific risk reductions presented, which is necessary to obtain valid results. Some analysts argue the WTP estimates should be proportional (not just different) to risk changes based on theoretical analysis (Hammitt and Graham, 1999), but proportionality is seldom seen in any CV studies for risk or other nonmarket goods. Since a point estimate of VSL is calculated by dividing estimated WTP by the stated risk reduction, if WTP is not exactly proportional to stated risk reduction, different VSL estimates will result from different (and probably arbitrary) choices of the magnitude of risk reduction . The same CV study may therefore provide more than one VSL estimate. A meta-analysis could examine the relationship between the size of the risk change and the VSL, including all the estimates from all the CV studies that meet the screening criteria. Some patterns may emerge that would be helpful in determining how to combine estimates across studies, and how much weight to give to multiple and differing estimates from the same study. Although theory suggests that WTP should be nearly proportional to stated risk reduction, very few CV studies have satisfied this criterion (Hammitt and Graham, 1999; Corso et al., in press).

If meta-analytic techniques are not pursued, or existing meta-analyses cannot be exploited, the Council suggests going back to Exhibit 4 after a much more limited culling of the studies. Then, the figures would show a very skewed distribution with most of the estimates falling at the lower end, and a very long flat tail at the high end. This suggests that the weight of the evidence might best be characterized by something other than a simple arithmetic mean.

b) Adjusting for Income Growth. EPA proposes to value future changes in mortality risk using a VSL which increases to account for anticipated increases in real income. This approach is conceptually appropriate, but there is substantial uncertainty about the appropriate income elasticity. Careful meta-analysis of existing studies may lead to some narrowing of the proposed range of income elasticities (0.08 - 1.0). EPA should also consider the possibility that the relevant income elasticity is larger than 1.0, as suggested by some international comparisons (e.g., Liu et al., 1997) and a time-series study in Taiwan (Hammitt et al., 2000). Given the uncertainty in estimates of the income elasticity, it would be prudent to avoid any adjustment.

c) Adjusting for Lagged Effects. The proposal to discount for any latency before the period in which mortality risk would be altered is conceptually appropriate (although this latency is not clearly defined in the valuation sections). The discount rate should be the same as is used to discount other monetary values (benefits and costs). Since the value that should be discounted is the future VSL, discounting and adjustments for growing real income will partially offset each other.

d) Adjusting the VSL for Specific Characteristics of Affected Populations. The Council has three main comments on this process:

1) Conceptual issues concerning adjustments to VSLs for some factors but not others. Conventional benefit-cost analysis is based on the identification of potential Pareto improvements (i.e., the "Kaldor-Hicks criterion" or "compensation test"). Straightforward application of the Kaldor-Hicks criterion implies EPA should account for any and all individual characteristics that influence an individual's (or household's) willingness to pay for reduced health risk. To the extent that these adjustments conflict with equity principles (e.g., because they give greater weight to risks to higher-income populations), To the extent that these adjustments conflict with equity principles, one may wish to supplement the benefit-cost analysis with an explicit assessment of the distributional consequences of the policy across different subpopulations defined by income or other characteristics. Alternatively, one could choose an alternative to the Kaldor-Hicks criterion, which would provide the underpinnings for an alternative to conventional benefit-cost analysis is a reference to the VSL adjustment proposed by Pratt and Zeckhauser (1996). In this case, however, it is not necessarily appropriate to rely on standard theory to argue for other adjustments.

2) Age and baseline risk. While it is theoretically clear that VSL may depend on age, the magnitude and even direction of any necessary adjustment is uncertain. Theoretical studies (e.g., Shepard and Zeckhauser, 1984; Rosen, 1999 [CHECK DATE]; Ng, 1992) suggest that VSL is an inverted-U shaped function of age, but the location of the peak, and the differences between peak VSL and VSL at other ages, are both very sensitive to alternative assumptions about discounting and other factors. Empirical studies have provided little insight, as many have included only linear age terms which are clearly inadequate for extrapolation. The age-specific factors based on work by Jones-Lee and colleagues, and the adjustment described in Appendix E, appear reasonable, but there should be appropriate recognition of the uncertainty about the magnitude of this adjustment.

The proposed approach is conceptually appropriate if age is a sufficient explanation for differential sensitivity to air pollution. If sensitivity is more closely related to baseline mortality risk or life expectancy (i.e., younger people in poor health may be as sensitive as older people in good health), then an additional adjustment for baseline risk is appropriate. This adjustment depends on whether an individual's high baseline risk is due to air pollution (and so reduced air pollution will substantially reduce risk), or to competing risks (so reduced air pollution will have a limited effect on risk). In the former case, the individual's WTP for reduced air pollution will be relatively large; in the latter case, it will be relatively small (Eeckhoudt and Hammitt, in press). EPA also proposes to use the assumed relationship between VSL and age to estimate the VSL for a 40 year old from labor-market studies estimating the VSL of workers within an age range. This adjustment appears to be correct in principle, but is sensitive to the assumed relationship between VSL and age.

3) Income. The question about when to adjust for differences in individual characteristics seems sharpest with regard to adjustments for differences in income. The logic of adjusting for assumed increases in income over time seems to imply that VSL should also be adjusted for current and future cross-sectional differences in income. However, such adjustments

do not appear to be practical, since they would require very disaggregate modeling of changes in air quality and human exposure to air pollution. Moreover, the Council suspects that adjustments for income would have little effect on estimated benefits, because effects of fine particles, ozone, and other major pollutants are distributed across broad geographic areas which containing wide variations in income.

e) Alternatives to VSL. If benefit-cost analysis is to be conducted in accordance with conventional, Kaldor-Hicks foundations, the Council agrees with EPA that VSL is the conceptually appropriate method for assessing the benefits of avoided premature mortality. Alternative measures, such as the value of a statistical life-year (VSLY) or the value of a quality-adjusted life-year (QALY), are not consistent with the standard theory of individual WTP for mortality risk reduction. Nevertheless, these alternative metrics have some appeal and are widely used to evaluate other public-health interventions. Hence, the Council suggests that EPA consider reporting some results in terms of implied cost-effectiveness (e.g., dollars per life year).

However, the EPA should be insistent that such measures are only valid comparisons of the relative desirability of alternative policies if the physical benefit measure in the denominator of this calculation exhaustively captures all of the benefits from a policy. Suppose an air-pollution control regulation resulted not only in avoided premature mortality, but also in improved aesthetics, healthier ecosystems, and less damage to buildings and monuments. Then, assigning the entire cost of the policy only to avoided premature mortality yields an underestimate of the true cost-effectiveness of the policy. If the benefits of a policy are heterogeneous, they cannot be aggregated if left in their natural physical units. Some type of valuation of the physical benefits is typically necessary.

f) Discounting future benefits and costs is conceptually appropriate and practically important, especially for programs such as Title VI for which benefits and costs may be greatly separated in time. Unfortunately, there is substantial uncertainty about the appropriate discount rate to use. The values of 5% (with sensitivity analysis of 3% and 7%) proposed in Appendix B are consistent with current recommendations, although recent work by Weitzman (2001, 1998) suggests that it may be appropriate to use different discount rates depending on the period over which the discounting is applied. The Council supports EPA's proposed choice of discount rates, but recommends that EPA acknowledge conceptual and practical uncertainties about this topic.

It would be informative to display low/central/high estimates of all relevant quantities as a function of the discount rate used in the analysis. Discount rates of 3, 5 and 7 are fairly standard possibilities. It is often useful also to plot the time profiles of costs and of benefits, without any discounting, so that readers can assimilate the intertemporal tradeoffs that are being made with any specific policy choice.

g) Asthma Morbidity. In a small footnote, the Analytical Plan mentions that asthma attacks are not being valued per discussions with OMB on the Heavy Duty Diesel rule Regulatory Impact Analysis. Apparently, OMB has argued that the Rowe and Chestnut (1986) (NEED FULL CITATION) study should not be used because the sample was small, the asthma endpoint was self defined, and the contingent valuation study design is outdated. It is actually no older or more outdated than the other CV studies being used to value days with respiratory symptoms, but it is true that it was a small sample and it was published as an EPA report and in an AWMA proceedings rather than a journal. The sample was 65 adults, but payment card elicitation of WTP was used, which does not require as large a sample size as referendum style questions.

However, the fact that the endpoint was self defined by the subjects is a strength of the study for the purposes of this assessment, not a weakness. The health endpoint we need to value is a self reported asthma aggravation, as defined in a daily diary study with a panel of asthmatics. The Rowe and Chestnut study was designed to match this endpoint and was conducted with a sample of asthmatics who had participated as panel members in a daily diary study. They were asked to say on a seven-point asthma symptom severity scale-the same one they had been using in the symptom diary--what was the highest level of symptoms that they would consider a good asthma day. Bad was then defined for each subject as any day with asthma symptoms more severe than that. They were asked WTP questions for reducing the frequencies of "bad asthma days". The annual average number of bad asthma days for the sample was 74, which matches closely the annual frequency of "asthma attacks" in the Whittemore and Korn sample.

Emergency room visits and hospitalizations for asthma are captured as other endpoints in the assessment, although they are valued only with cost of illness (COI) estimates because WTP values are not available. Such events are not reflected in the asthma panel studies because they are rare events and seldom occur during the panel studies involving asthmatics who are aware of their disease and undertake to manage it. The asthma morbidity panel studies are capturing day-to-day fluctuations in asthma symptoms, which would be expected to include some days on which the symptoms are severe enough to restrict activities and perhaps result in missed school or work, but would also include many days when symptoms are noticeable but are readily controlled with treatment and normal activities are undertaken. Developing average COI estimates per asthma symptom-day will be very difficult with available data, because it will require an allocation of annual costs for doctor visits and medication to individual symptom-days, and requires some information about the frequencies of symptom-days for the entire population with asthma, and some information of the share of symptom days that result in activity restriction and missed school or work. However, it is useful to see what can be done to develop COI estimates given the limited and undervalued WTP estimates available.

6.2. Valuation of Ecological Effects

The first Prospective Analysis acknowledged that the estimates of economic value for environmental effects are not comprehensive. Quantitative estimates were developed for effects on commercial forests and recreational fisheries in the Adirondacks. Illustrative estimates are also made for carbon sequestration in commercial timber, estuarine eutrophication (Chesapeake Bay, Tampa Bay, and Long Island Sound), forest aesthetics, and toxicity impacts (in the form of fish consumption advisories) on recreational fishing. Visibility aesthetics at national parks and effect of air pollution on commercial crops are treated elsewhere, with no significant changes in estimation methods proposed at this time.

The revisions proposed by EPA for the Second Prospective Analysis, as presented in Chapter 8 and discussed by teleconference on June 22 and June 25, 2001 are two:

a) Add a qualitative discussion of progress in the literature regarding economic valuation of ecosystem service flows, as they are impacted by pollution. Work by Bockstael, Costanza, et al. (1995) and others on the effects of land use decisions on ecosystem service flows in the Patuxent watershed in Maryland is an example of collaborative efforts with ecologists and economists to model and quantify the value of changes in ecosystem service flows.

b) Consider updating the estimates regarding effects of nitrogen deposition on estuaries, based on new modeling work currently underway by EPA.

These are reasonable next steps. The Council urges EPA to continue to make progress toward more comprehensive estimates of the value of changes in natural environments achieved under the CAA. There is agreement among Council members that effects upon natural environments that are not quantified and monetized will tend to be overlooked and EPA should take measures to avoid this outcome. There are differing perspectives among Council members about how best to further the goals, but there is agreement regarding two goals: a) continue the progress toward more comprehensive environmental effects estimates and b) effectively communicate to policy makers the potential significance of environmental effects that are not quantified.

Some Council members are comfortable with relatively ad hoc procedures to develop a set of place holder numbers to keep the ecological services on the table, at least as a sensitivity analysis. However, most agree that quantitative estimates presented in the 812 report need to have firm footing in ecological sciences and economics principles consistent with the cost-benefit framework. Areas of current research that might suggest ways to develop more comprehensive estimates of value for changes in ecosystem services include EPA's work on the Chesapeake Bay and Tampa Bay estuaries (CITATIONS), the U.S. Army Corps of Engineers work on the effects of water diversions on the Everglades (CITATIONS), research funded by the National Science Foundation on ecological services (CITATIONS), and the European precautionary approach.

Making a distinction between natural resources and ecosystem services is an organization/presentation issue has merit, but these effects result from the same pollution impact processes and need to be presented together, as is now done in Appendix E in the first prospective report. There could be improved clarity in the way the terms ecological effects and ecological services have been used. However, the interconnections between the effects of air pollutants on natural resources and on ecosystem services needs to be maintained in the presentation. Appendix E does this by starting with a discussion of the processes by which air pollutants affect natural systems. This is appropriate and could even be expanded. For example, the processes by which acidification of lakes in the Adirondacks affect the stocks of fish of interest to recreational anglers are part of the same processes by which acid deposition may impact the quality of ecosystem services. Similarly, the processes by which nitrogen deposition may affect commercial fisheries are part of the same processes by which nitrogen deposition may affect the ecosystem services of estuaries. However, merely listing ecosystem services alongside the commercial and recreational activities of people does not do justice to the importance of ecosystem services. They actually underlie most of the quantified effects that we would classify as natural resources. Therefore, effects of environmental pollutants on ecological service flows may be presented as the organizing principle, with effects on commercial and recreational activities being a subset of these.

The Council suggests that EPA convene a panel to develop a preliminary approach to valuation of the effects of air pollution and deposition on ecological service flows. The SAB workshop on public values for ecosystems addressed valuation issues from various social science perspectives. Progress is being made in the literature on the development of an appropriate conceptual approach for valuation of incremental changes in quality/quantity of ecosystem services, but further conceptual and empirical work is needed in the physical sciences and in the social sciences before even a conceptual approach for the 812 analysis could be well defined and accepted by the various disciplines involved. Empirical work to implement would then be needed. The panel might start with a case study such as the effects of nitrogen deposition on the Chesapeake Bay estuary, which is already included with partial quantification in the 812 analysis.

While this primary research and analysis effort is underway, EPA may be able to develop ways to present partially quantified information on changes in environmental quality achieved by the CAAA to more effectively communicate what we can say about progress toward protection of ecosystem service flows under the CAAA. For example, maps showing differences in deposition with the CAAA and without, such as those included in the air quality modeling appendix of the First Prospective Analysis, are very informative. It may be possible to overlay this information on changes in environmental quality with information on the locations of sensitive and at risk resources or ecosystems.

7. ASSESSMENT OF COSTS

The Council appreciates that the EPA understands the distinction between the direct costs of air quality regulations and their broader social costs. The first section in this chapter briefly reviews the EPA's plans for measuring the more obvious direct costs. The second section tackles the thornier problems of (a) tracking and measuring the wider social costs of regulation stemming from the propagation of regulatory impacts throughout the economy via interconnected markets, and (b) accounting for incumbent distortions in the allocation of resources (due to pre-existing taxes or non-competitive behavior) and the role of these distortions in aggravating the additional losses from air quality regulation.

7.1. Direct Costs

For direct costs, the first prospective analysis used the Emission Reduction and Cost Analysis Model (ERCAM) for non-utility sources and the Integrated Planning Model (IPM) for utilities, with results converted into total annualized costs (TAC) in 2000 and 2010. The analytical plan proposes similar procedures for the second prospective analysis, but extending to 2020, using a three percent discount rate, incorporating new regulations and cost estimates, and disaggregating by Title and State. The plan seems appropriate, although some minor questions remain.

a) The descriptions of the models are brief, so it is difficult to tell exactly what they do. One can assume they are an accounting framework for direct costs of added scrubbers or other pollution control equipment, plus the cost differential for purchase of low-sulfur fuel, etc. To what extent do they capture the cost of upstream "process changes" to reduce pollution, rather than just end-of-pipe pollution control equipment to deal with it once it has been created?

b) The Panel encourages the 812 Project Team to consider econometric estimation of costs (such as Carlson, Cropper et al., 2000; Morgenstern et al.; 1998, Barbara and McConnell, 1986; and Barbara and McConnell, 1990), both because econometric models can capture the cost of process changes and because they can provide valuable error bounds, at least conditional on the appropriateness of the estimating specification.

c) It is possible that some of the observed direct costs may not be "necessary" to comply with the CAAA, if managers mistakenly spend more than necessary or because they intentionally spend more than necessary to achieve other (non-CAA) objectives. However, it is likely that competitive pressures will act, sooner or later, to provoke cost-minimizing behavior, subject to the constraints of regulation.

d) There is some question about how the models capture fixed costs, especially with growth over time. How many additional plants are assumed and what are the additional fixed costs, relative to the marginal costs of these additional units?

e) Concerning mobile source costs (especially for zero emission vehicles) there appears to be some discussion about incorporating learning effects in the cost estimates based on Morgenstern et al. (1998). Was this the only place learning was incorporated? It is not clear that the proposed analysis will actually reflect a learning curve effect.

For vehicles in inspection/maintenance areas, there is no indication that the "time burden" of these regulations is being captured. The out-of-pocket cost of a vehicle inspection underestimates the cost of the program because it neglects the opportunity cost of time for the vehicle owner. These opportunity costs may swamp the out-of-pocket costs. The out-of-pocket cost of a vehicle inspection can be swamped by the opportunity costs of time for many higher-income drivers, and the time-costs are non-zero even for most low-income drivers. To assume that the time costs of this regulation are zero will bias downward the cost estimates of these programs. To the extent that inspection/maintenance programs for stationary sources also divert resources of the firm being inspected, these costs will also be understated. What is being done about imputing these implicit costs of such programs?

The two most visible hybrid vehicles, the Honda Insight and the Toyota Prius, are currently in short supply, with consumers willing to wait several months for delivery of a vehicle. There is relatively little discussion of these technologies in the Blueprint. It has been suggested that the selling price of these vehicles is vastly subsidized by the manufacturers in order to sell enough vehicles to generate customer acceptance and familiarity. It is not clear when hybrids (or true zero emission vehicles) will trade at market-clearing prices that reflect their marginal costs of production (namely, under competitive and efficient conditions). How does the analysis propose to deal with these complications in the nascent market for alternative-fuel vehicles? Or is the problem of alternative-fuel vehicles and their market idiosyncracies sufficiently small over the next few decades that it does not warrant being addressed?

f) To what extent have the ERCAM/IPM cost estimates for non-utility point sources been compared with the Morgen stern et al. [NEED FULL CITATION] estimates? A number of other cost studies have also been done, likewise using econometric analysis with the Census plant level data. An effort to compare the results from these econometric cost models with the ERCAM results (for approximately comparable control conditions) would help in developing an evaluation of the potential sources of error and associated uncertainties in the cost estimates.

e) The data from the new Pollution Abatement and Control Expenditures (PACE) has been collected but not as yet analyzed (contrary to statements at the meeting). Is the Agency planning to use this resource?

f) Costs of reducing emissions (ERCAM and IPM). As a point of clarification, it would be helpful to know whether marginal abatement costs are assumed to be constant, or to increase over time and with the current level of abatement. For IPM, for example, successive reductions by retrofit of existing plants with new technology would seem to involve increasing MAC. For new plants with new technology, it is possible that marginal abatement costs could be very high indeed. In all cases, it would seem that marginal abatement costs would depend on the technology in place and the extent to which some abatement has already been achieved. How is this handled, for forecasts that run decades into the future?

7.2. Estimating Overall Social Costs

The Council finds that the Analytical Plan does not contain a sufficiently thorough rationale for the use of a CGE model in the Second Prospective Analysis. The reasons for using a CGE model can be listed and discussed here.

First, a CGE model can allow feedback effects from policies to relative prices of goods and factors of production, which can lead to re-allocation of resources between sectors, which is important if some sectors have higher emissions than others. The Analytical Plan does not contemplate using a CGE model in this way, however. The Retrospective Analysis used the Jorgenson-Wilcoxen CGE model for this purpose, but the Blueprint indicates that this will not be done for the Second Prospective Analysis. Instead, a CGE will be a post-processing tool.

Second, even as a post-processing tool, a CGE model can be useful to estimate the difference between direct costs and social costs. Differences arise any time market prices deviate from social values. However, the major such deviation would arise because of pre-existing taxes or pre-existing regulations. But the Analytical Plan explains that EPA does not intend to include tax interaction effects. It is not clear why one would want a CGE model without tax interaction effects and non-separable measures of the effects of air pollution on preferences. The Analytical Plan does not indicate for what other reason social costs might be expected to deviate from direct costs using market prices (e.g. the cost of scrubbers, the cost differential for low-sulfur fuel, etc.).

Third, a CGE model can include productivity-linked benefits (e.g., avoided health effects), but a CGE model is not required to be able to do so. The Analytical Plan mentions that the Jorgenson/Ho/Wilcoxen model might include such effects. That model includes tax-interaction effects and so would be particularly valuable to use for the Prospective Analysis.

However, it does not allow for spatial differences in emissions and the effects of air pollution on preferences through the health impacts.

Fourth, a CGE model can predict sectoral effects, regional effects, employment, investment, and many other outcomes of policy. But it is not clear how those outcomes would be employed in arriving at the bottom line, an estimate of the total cost of the CAAA.

It is thus reasonable to question why the plan contemplates using a CGE model at all. The Council would like to see a CGE model used to do all of these things, but the contemplated use of CGE models would not encompass the first objective. And the plan does not explain its goals for the fourth objective.

The descriptions of the models that might be used for the fourth objective vary widely. The models were designed for different purposes, under different beliefs. One cannot choose among them before making some basic decisions: what is it that EPA is trying to accomplish by the use of a CGE model? Is it necessary to measure effects on growth, for which a dynamic model is crucial? Does labor supply vary significantly (or is it sufficient to use a simpler fixed-labor model)? Is capital internationally mobile (such that it is possible to fix the world-wide rate of return)? Is the U.S. economy open, like each of the regional models? Probably far less so, meaning that the sum of the outcomes of any complete set of regional models will not be the same as the collective outcome for the whole United States.

The Analytical Plan needs to be clear about what is the question that the EPA is trying to answer. Only then is it possible to discuss the appropriate tool to answer that question.

As an aside, the Council notes an apparent error in quotes of prior SAB advice that the "tax interaction effect is 1.25 to 1.35 times any increase in direct costs." The 1.25 to 1.35 range was meant to be a range on the approximate central estimate, rather than a set of confidence bounds on the individual values corresponding to any particular context. It would be more accurate to say that "the central estimate is about 1.3 times direct costs, but heterogeneity and uncertainty mean that the best factor to use might be 1.0 or less in some cases, or 2.0 or more in other cases." Without considering the sectorial composition of the regulations and the existing structure of taxes it would not be possible to select a value.

The Council recommends that the EPA reconsider its decision concerning the tax interaction effect in the Second Prospective Analysis. These effects are actually fairly well-understood. What "economists are still exploring" is not the existence of the tax interaction effect, but its specific magnitudes under different circumstances. The size of the effect depends on whether capital is internationally mobile, for example, so it will differ for different countries in different years. It also depends on the size of the different elasticity parameters for particular industries with particular regulations dealing with particular pollutants. Different studies get different answers because they study different circumstances, not because they disagree in fundamental ways.

The Analytical Plan identifies the primary objective of the CGE analysis as investigating the second-best effects of tax related distortions (see p. 48). These models incorporate a number of different assumptions from EPA's separate cost-calculation enterprise. The discussion in the Blueprint focuses on choice of an appropriate CGE model, rather than on how it would be used, once selected. The Council requested some clarification prior to the July 9-10 meeting, but the EPA response to the question focused on growth effects. Differences across CGE models in their assumptions about (or treatment of) factor prices, and the manner in which they introduce abatement costs (e.g., contrast Jorgenson-Wilcoxen and Hazilla-Kopp) are not discussed. These differences can be important to the utility of these models in assessing the economic impacts of the CAAA.

In any CGE model, incorporation of non-separable environmental effects on consumer preferences is essential if the CGE-produced cost estimates are to be consistent with the assumptions underlying the separate benefits estimation. This would require:

a) modification in calibration procedures used for baseline year (to be consistent with air quality conditions); current calibration practices set allocation parameters so the baseline solution matches the expenditure and income flows. With non separable pollution in preferences the calibration must also match the emissions and ambient concentrations that drive final demands for health related goods and services;

b) introduction of spatial resolution into CGE models; currently spatial delineation is nonexistent in the existing CGE models; thus there is no basis for distinguishing the effects of different amounts of air pollution for different individuals.

[COULD USE A LITTLE ELABORATION…]

8. UNCERTAINTY ANALYSIS

A more explicit and thoughtful treatment of uncertainty is one of the major advances in the proposed Second Prospective Analysis. In its previous studies, EPA implicitly assumed a greater degree of certainty in its estimates than was justified. Showing the uncertainties explicitly will give decision-makers a better idea of what we know. Since current confidence intervals will be large, the Council's expectation is that decision-makers will then ask for the most cost-effective ways of reducing uncertainty. This will sharpen the focus of research and improve the efficiency with which research resources are allocated.

8.1. General Comments

The Council recommends that the EPA distinguish three varieties of uncertainty: a) unmeasured variability; b) model uncertainty; and c) unpredictable policy-implementation choices. The first variety includes things like the day-to-day variability in emissions or in ambient air quality levels from hour to hour. Examples of model uncertainty include the question of which air pollutants cause premature mortality at current ambient levels (Hazardous Air Pollutants, PM10, PM 2.5, Ozone, Carbon Monoxide, Nitrous Oxides, or others), or, the lack of resolution about the true form of a particular exposure-response relationship (it may not actually be proportional). Examples of unpredictable policy-implementation choices include the question of whether New Source Performance Standards, or other policies, will be actively enforced.

Variability, the first variety of uncertainty, should properly be treated within a Monte Carlo framework. Some degree of model uncertainty can also be treated within this framework. The rest-the policy implementation uncertainty should be handled by "conditional probability" or "scenario" models. This framework presumes a posterior probability density function (pdf) that is conditional on a particular model or policy. For example, what is the posterior probability density function for the resulting health effects (e.g., the pdf for the number of premature deaths. given a proportional exposure-response function? Similarly, what is the posterior probability density function for the same effects given that current emissions regulations will be enforced strictly?.

The previous two 812 studies gave short shrift to the second or third varieties of uncertainty. The current study should do a better job. One example may help. Estimating the benefits of HAP abatement is problematic primarily, because of model uncertainty . Conditional forecasts (scenarios) can make the model uncertainties explicit in developing both point and interval estimates for the likely benefits from HAP abatement for each plausible exposure-response relationship.

For benefit and cost estimates, the central estimate and range (i.e., low and high) are informative only when the procedures used to compute them can be documented with reference to some statistical model (e.g., error attributed to the estimation process) or another systematic process identifying the sources and magnitudes of variations in the parameters and variables contributing to these benefit or cost estimates.

Uncertainties in the costs of abatement in response to a regulation can differ ex ante and ex post. In evaluating a prospective regulation, the EPA often relies on the presumption .that existing technologies will be used and that their costs will remain fixed. However, if flexibility exists in implementing a regulation, the regulated entity is likely to find lower-cost methods of compliance, either through using other technologies or changes in practice, or through a reduction in the cost of the existing technology through learning effects or scale economies. Frequently, the EPA engages in explicit technology forcing, as with automobile emissions regulations. When technologies are available, companies find much cheaper ways of complying, as with sulfur dioxide abatement under the 1990 CAA. After the fact, it can be all but impossible to isolate the true increased costs of a regulation. For instance, what has been the cost of the 1970 CAA automobile emissions standards? At best, this cost uncertainty can be quantified by specifying a probability density function. In most cases, the probability density function will cover a wide range. However, this will be the best indication of current uncertainty. The influence of selected components to the cost estimates, rather than a full simulation analysis, may be more informative. [DO WE STILL CONCUR ON THIS LAST POINT??]

The benefits of a regulation are subject to still greater uncertainty. For example, the specific pollutants that are responsible for premature mortality are not known with certainty. Are all types of PM 2.5 particles equally toxic? Are current levels of carbon monoxide or benzene harmful? As ambient concentrations fall, there is considerable uncertainty about the additional health benefit of further abatement. A further uncertainty concerns the identities of the susceptible populations and how susceptible they actually are. Age distributions are not constant across areas, and this factor can affect the expected benefits from air quality improvements. In many cases, the uncertainty extends to whether there is any additional benefit at all (e.g., the case of for lowering exposure from current levels to some HAPS.).

The Council commends EPA for moving to deal with uncertainties explicitly. We advise them to deal explicitly with all three types of uncertainty identified above. The First Prospective analysis innovated by including mechanistic/Monte Carlo construction of uncertainty estimates for benefit measures. However, the Second Prospective Analysis can expand uncertainty analysis beyond this point with the objective of identifying much broader sources of uncertainty.

The Council recommends that transparency serve as the basic guide for the uncertainty analysis. In practice this implies identifying the components of the benefit and cost measure, specifying how the elements leading to a benefit estimate or cost were altered to reflect uncertainty -- whether different baseline conditions were considered, functional forms, Monte Carlo simulations or scenario to describe related policy initiatives.

The structure could be outlined in a series of tables describing each of the following:

Baseline and Policy Condition

Air Quality Modeling

Modeling of Physical Effects/Risks

Economic Valuation of Outcomes

In each category the assumptions, potential source of uncertainty and its treatment in the uncertainty analysis could be described.

8.2. Air Quality Modeling and Emissions Considerations

No matter what approach is adopted for assessing uncertainty, it is imperative that the intermediate air quality model outputs used as inputs to the cost-benefit analysis be compared with actual measurements following model evaluation protocols, such as briefly outlined in Section 4. In designing the comparisons, it should be noted that it is possible to 'validate' an ozone model using actual maximum eight-hour concentrations and then to apply the validated model to an assessment of crop damage that uses an entirely different ozone statistic. Similarly, it is possible to assess model performance for long-term PM levels using IMPROVE data to apply the model to long term predictions in urban areas. However, the limitations of these comparisons definitely need to be clearly stated.

There are three possibly-relevant scenario features that are not specifically addressed in the Analytical Plan. Some qualitative statement of the uncertainties associated with their omission would be appropriate.

a) Climate Change: Specifically, the scenarios for future sulfur dioxide emissions imply reductions in the cooling effect of sulfate aerosol. To the extent that this happens, it will y impact predictions of global warming. There were substantial debates about this at the Intergovernmental Panel on Climate Change (IPCC) meetings prior to the Panel issuing its report (i.e., what emission scenario should be used?). Perhaps some wording can be borrowed from that report to describe this uncertainty.

b) Wildfire impacts: As we approach this wildfire season, there is a great deal of discussion about the health impacts of these events. There is some discussion about claiming prescribed burning as a control measure. If this is done in the context of the CAAA, it should be recognized.

c) Supplemental diesel power: Many industrial facilities are exploring or adopting the use of supplemental diesel equipment for on-site electricity generation. These sources appear not to be regulated in the same way as traditional electrical generating units, but they can potentially produce substantial amounts of PM and nitrous oxides.

Finally, the AQMS supports the use of a Monte Carlo method to estimate the high and low benefit/cost estimates provided that the underlying distributions can be reliably or meaningfully constructed. If EPA has high enough confidence that such distributions can indeed be identified, the Monte Carlo approach will constitute a significant improvement over the approach used in the First Prospective. In Chapter 9 of the Analytical Plan, it is suggested that the high and low estimates be defined by the 90 percent confidence limits. But in Chapter 10, they were defined as the 95 percent confidence limits. Substantially more random events will have to be generated to secure adequate resolution on a set of 95 percent confidence limits.

8.3. Mechanics of Monte Carlo Simulations

Chapter 9 of the Draft Analytical Plan lists three alternative uncertainty analysis strategies but appears to identify the third one (Probabilistic Simulation) solely with Monte Carlo simulation methods (page 9-2). EPA should be encouraged to investigate computationally efficient alternatives to traditional Monte Carlo approaches, with optimized sampling/aggregation strategies such as efficient LHS (SPELL OUT ACRONYM) algorithms, stochastic response surface methods, and high-dimensional model representation methods.

In the Monte Carlo simulations, comprehensive error distributions around central estimates of net benefits will be generated by specifying distributions for key variables and parameters in all components of the analysis, based on subjective (or expert) judgment. Plugged in to these models, the most likely values of these variables and parameters can be presumed to generate the most likely values for benefits, costs, and net benefits. But since each ingredient in these calculations is characterized by some degree of uncertainty, a large number of random draws can be made from the set of distributions that quantify these uncertainties and the researcher can build up a sampling distribution of possible forecasting outcomes.

It was not clear from the description how the ranges of values for parameters (or variables) would be developed. What functional forms will be assumed for the distributions of the uncertain quantities in these forecasts? EPA should reflect current expert judgment in choosing an appropriate probability density function to characterize each type of uncertainty, as opposed to adopting just convenient uniform or normal distributions as default assumptions. If more complicated distributional assumptions are called for, recall that the probability integral transformation allows one to convert a uniform random variable on the 0,1 interval into any arbitrarily specified univariate distribution. An easy normal distribution will be appropriate for some uncertain qualities, but not for all. In some cases, the quantity must be strictly non-negative to be plausible. For these, the error might be assumed to be multiplicative and lognormal, with an expected value of one.

A major dimension of uncertainty is the non-independence of variables. It is not apparent in the Draft Analytical Plan whether the 812 Project Team will consider the possibility that at least some of the uncertain quantities will be correlated. The Monte Carlo approach described in the Draft Analytical Plan does not take account of the potential for inconsistencies among the sets of values randomly drawn from each variable in the cost models, for example. If oil prices rise, natural gas and coal prices are also likely to rise. Inconsistencies can also arise because the values are technically related (e.g., a heat rate for a BTG unit is associated with a scale and fuel type; some values may be inconsistent outside specific ranges). Or, they can result because the variables in question are a joint result of some optimization process. If a subset of forecasted variables is uncertain but correlated, simply taking independent random draws from the assumed marginal distributions for each variable can lead to an incorrect distribution for a function of these random variables. As a simple illustration, if two random variables are positively correlated, the variance of their sum will be underestimated if their correlation is erroneously assumed to be zero.

If a jointly normal distribution is needed (perhaps for the logs of a correlated set of strictly non-negative variables), then a set of independent draws from a standard normal distribution can be combined with the Cholesky factorization of the covariance matrix assumed for the joint normal distribution to produce jointly normally distributed random variables with specified variances and covariances. This can be combined, to good effect, with the assumption of lognormal/unit-mean marginal distributions and multiplicative errors.

Incidentally, there should be some concern about the Monte Carlo analysis concerning the value of a statistical life. The Council advocates that the EPA employ existing meta-analyses concerning the appropriate VSL to use in its analyses, or that it conduct its own meta-analysis. However, if, for example, the set of 16 studies identified in Appendix D is actually to be used, a procedure that samples randomly from the 16 point estimates in this set will miss the uncertainty associated with each of these point estimates. It is not clear from the report in Appendix D whether each one of these 16 studies reports an interval estimate to go with its point estimate of the VSL. If they do, this information (at a minimum) should be incorporated into the assumed distribution for the "true but unknown" VSL before these 16 point estimates are employed for the Monte Carlo analysis. But none of these model-dependent interval estimates captures the additional basic uncertainty about the appropriateness of the specification that has generated it. Furthermore, there is no guarantee that the independently calculated VSL point estimates from studies in 16 different contexts should be expected to represent the distribution of possible VSL estimates associated with the precise contexts in question for the CAAA.

8.4. Uncertainties as They Relate to Estimates of Health and Ecological Effects

In Table 9-1 of the draft Analytical Plan, under "No quantification of health effects associated with exposure to air toxics", the "Likely Significance" indicates a "potentially major" significance. This is clearly not the case for carcinogenesis, as was amply demonstrated in Council's review in the Retrospective analysis. Even when using the highly conservative risk estimation procedures based on IRIS data, there were no credible estimates for a significant cancer risk in the U.S. population. The document should either conclude that the cancer benefits of Title III are negligible, or provide an upper bound risk estimate with a note explaining how conservative that estimate is likely to be, and flag that uncertainty as part of the 812 Analysis for at least one HAP . However, the concerns about the unknown risk for adverse health effects such as neurotoxicity, reproductive toxicity and developmental toxicity should be retained until better databases become available for these HAPs.

We are now at a juncture where EPA can test the performance of the 1990 to 2000 projections against with actual emission changes, and actual cost incurred by various sectors or CAAA titles to reduce emissions. We may even see the adverse impact on mobile source projections due to vehicle emissions caused by the growing popularity of sport utility vehicles. The uncertainty analysis would be significantly strengthened by this type of validation.

The Council also recommends that a separate section be devoted to uncertainty with respect to commercially exploited natural resources and non-market ecological service flows. These uncertainties, especially with respect to the benefits of the CAAA for non-market ecological services, have historically been assumed to be extremely large and unquantified. Nevertheless, their potentially significant role in determining the overall benefits and costs of adjustments to the CAAA warrants their inclusion in all analyses on as equal a footing as possible. If imprecision in their measurement is allowed to result in recognition only as a footnote or a parenthetical notation, casual observers may mistake their contribution as zero. In the absence of concern for ecological benefits of the CAAA, one Council member has wryly observed that the Agency looks more like the Human Health Protection Agency, rather than the Environmental Protection Agency.

8.5. Proposed Strategy for Capturing Uncertainty in VSL Estimates

The Draft Analytical Plan proposes to capture the uncertainty in the value to be used to monetize a statistical life by Monte-Carlo sampling from the distribution of the 16 "credible" VSL studies identified in Appendix D. However, these 16 studies do not purport to be measures the VSL under identical conditions, in identical contexts. It is still very likely that the observed differences in point estimates across these studies are due, at least in part, to differences in the choice scenarios faced by individuals in each sample. Ideally, what would be needed for the Monte Carlo analysis is a set of random draws from the true distribution of the VSL for this particular context (relevant to the money/premature-mortality tradeoffs that are implicit in the presence or absence of the CAAA regulations). The "right" VSL estimate corresponds to the correct context, and may not coincide with the average context (or, therefore, with the average VSL) in the set of studies used as references.

The 16 point estimates for VSL also do not convey the degree of uncertainty in each individual estimate. The averaging of these 16 independently generated point estimates ought to take into account the standard errors of these point estimates. Even these errors, however, will not capture possible errors due to misspecification, so they will not provide comprehensive error bounds.

9. RESULTS AGGREGATION AND REPORTING

9.1. General Comments

The Council's judgment concerning the role of disaggregation in the Second Prospective Analysis requires first reviewing the dimensions along which the EPA might attempt to disaggregate this benefit-cost analysis, and the reasons why each type of disaggregation might be desirable. One should begin by defining the "aggregate" result as the final summary value of net benefits (or, similarly, a single benefit-cost ratio for the entire CAAA). Some of the different dimensions along which the analysis could be disaggregated could include:

a) examining total benefits separately from total costs

1) disaggregating benefits by Title of the CAAA, by political jurisdiction, by airshed, by urban/rural, or by sociodemographic group, or by health endpoint or ecological endpoint, etc.

2) disaggregating costs by Title of the CAAA, by political jurisdiction, by industry/sector, by investors/consumers, by pollutant, etc.

b) considering net benefits (benefits minus costs)

1) exploring incidence of net benefits by jurisdiction or by airshed/watershed

2) exploring incidence of net benefits for types of individuals (e.g. urban/rural, rich/poor, etc.)

The presentation should continue to show these components of benefits as was done in the first prospective report.

Disaggregations of type (a) are descriptive. They are helpful for developing a clearer understanding, among the audience for the report, about the major components of the total benefits calculation. For example, avoided premature mortality benefits accruing to the elderly represent the lion's share of total benefits in the First Prospective Analysis. Disaggregation by health endpoint and sociodemographic group reveals this important understanding about the overall benefits analysis. Since aggregate benefits are assembled from these assorted component benefits, it is not too difficult for the Analysis to discuss these substantial components.

In contrast, disaggregations of type (b) allow us to consider the incidence of net benefits derived from these regulations that implement the CAAA. This type of disaggregation reveals the distributional consequences of the programs involved. Knowing that a certain region or group enjoys large benefits from the CAAA means something very different for their overall welfare according to whether they also bear a huge share of the costs, or whether they bear only a small share. Disaggregation of net benefits is a more challenging task than the separate benefit or cost disaggregations of type (a.). It is rare that all of the benefits and all of the costs, even for very specific air quality regulations, will accrue entirely to the same set of individuals. More typically, the benefits will accrue to one set of individuals and the costs will be borne by another. The two groups may overlap to some extent, but need not overlap much at all. When there is incomplete overlap, a program or regulation involves redistribution, which means there may be equity questions. The sector disaggregation, described in Section 3.1.a of this Advisory is a type (b) aggregation.

9.2. Title 6

The Council agrees that the benefits and costs of Title VI should be disaggregated from other Titles, because the interactions between effects of Title VI and other titles are limited (e.g., the actions taken to reduce emissions of ozone depleting substances are largely independent of those taken to comply with other titles, there is limited interaction among ozone depleting substances and other atmospheric constituents influenced by the CAAA), and because analysis of the benefits of Title VI requires a much greater time horizon.

9.3. Disaggregation of Benefits (Without Consideration of Costs)

Disaggregation of the benefit results, by category of effects (e.g., morbidity and mortality), has been very helpful in First Prospective Analysis. It helped both to clarify the sources of gains and to highlight areas where uncertainty in benefits estimates could be especially influential in determining the bottom line. In addition, however, it would be desirable to consider a two-way disaggregation of benefits by both pollutant and effect (e.g., effects of nitrogen oxides on human health and through water deposition as nutrients on estuarine resources). These types of effects, of course, are already the building blocks of the overall aggregated benefits measures that the Second Prospective will report as the bottom line. Why not make them it more explicit in the report?

It is very important to have some more-specific mechanisms to deal with the potential for jointness (nonseparabilities) between the effects of pollutants. The incremental effect of a unit of pollution on one particular health endpoint may depend upon the individual's current health status and upon the burden of other pollutants borne by the individual. The effects of different pollutants on any one health endpoint are unlikely to be entirely linear and additively separable.

An evaluation of the fundamental jointness between morbidity and mortality losses would also be desirable. For example, are utility losses attributed to chronic obstructive pulmonary disease (COPD) in final stages of life directly incorporated into the valuation of risk of premature death from these causes? Few instances of mortality from air pollutants do not include an associated pre-death period of morbidity. Recent research in non-market valuation suggests people do consider quality-of-life and transition to death in evaluating their tradeoffs for risk increments (e.g., Desvousges et al., Canadian studies, Cropper et al., and Johnson et al., for smoking [NEED FULL REFERENCES]).

Disaggregation of air quality improvement effects (in terms of health endpoints) for different regions or demographic groups should be structured to provide "cross-checks" with available data about the distribution of these endpoints in the population. The EPA should employ either actual measures or estimates of the overall number of cases being observed in U.S. as a whole, and in specific states or regions. This suggestion is relevant true for all intermediate physical measures of air quality effects, as well as for the projected changes in air quality themselves.

The Draft Analytical Plan proposes to use interpolation of point estimates [OF WHAT, IN WHICH YEARS?] to construct an aggregate present value (over a specified time period). However, when only a simple time trend determines the differences [IN WHAT??] with each year, it is not clear what is gained by this strategy.

9.4. Disaggregation of Costs

The Council observes that there is occasionally inadequate information in the analytical plan to allow it to suggest how the Second Prospective Analysis should undertake cost disaggregation.

a) It appears that cost analysis for point sources is largely based on the equivalent, in neoclassical economic terms, of a static model with constant returns to scale, so that new environmental regulations simply shift up unit costs of production. The discussion on pages 4-1 and 4-2 of the Draft Analytical Plan seem to suggest ERCAM (for non-utility point sources) has both capital and operating costs measured per ton of emissions controlled. It is not clear whether this is correct. Does this assume that emissions are (for a given level of control) a constant multiple of output? How do scale effects enter this approach? Are there differences [IN WHAT] for different fuel mixes? Both could imply nonseparabilities between production and abatement activities.

b) The CGE work of Jorgenson-Wilcoxen incorporates non-neutral technical change. The Council is concerned about inconsistencies here. The Jorgenson-Wilcoxen analysis also had consistent treatment of factor prices and progressive growth in capacity in each sector.

It appears from the description that ERCAM and IPM treat the cost as individual "snap shots" within a static framework, rather than as processes that evolve in response to regulations and the resulting adjustments in factor prices. It may be important to clarify the distinctions between the ERCAM/IPM models and the CGE models. We could easily attribute the difference in costs between the ERCAM/IPM model and the CGE results to [WHAT KIND OF] distortions when there is more going on than is captured by the ERCAM and IPM models.

Consistent geographic disaggregation would not be served by simply attributing pollution abatement costs to establishments where the productive capacity assumed responsible for emissions is located. The difficulty arises because these establishments are often part of large multi-state or international firms. Costs incurred in different locations are translated into higher prices and potentially lower profits. The higher prices are experienced in the locations where the firm's products are sold and the lower profits by the investors with ownership interests in the firm. To adequately measure the disaggregate costs we would need to consistently account for all these price and income effects at the household level, aggregating them along with the beneficial effects experienced by each of a representative set of households in each region. When these were aggregated to a regional level the result would offer a consistent picture of disaggregate net benefits. Other approaches will be subject to biases of unknown direction.

9.5. Disaggregation of Net Benefits (Benefits minus Costs)

Information about the distribution of net benefits will invite questions about the distributional consequences of the CAAA. Most economists are extremely hesitant to wander into discussions of fairness or equity. However, benefit-cost analysis itself makes default assumptions about equity that need to be kept in mind. Formal benefit-cost analysis typically presumes a Benthamite (utilitarian) social welfare function, with equal welfare weights on each individual's utility level. There is also a presumption that the marginal utility of income is constant across individuals. This set of assumptions is only one of a number of alternatives. Arrow's Impossibility Theorem proves that there is no single social welfare function that can simultaneously exhibit the full set of properties that would be desirable in a social welfare function, so any one that we pick will be a compromise. Just because economists have typically preferred the particular social welfare function that leads to conventional benefit-cost analysis does not mean that this function is the "right" one. It is merely convenient.

The fundamental building blocks for any social welfare function, however, are usually agreed to be individual utility functions. The benefits (or costs) to any single individual of some change in conditions is, in principle, measurable by the trade-offs he or she would be willing to make, typically between dollars (usually, income) and the level of the environmental public good in question--in this case, air quality. If an individual's willingness to pay for a change in the level of an environmental public good exceeds what he or she will pay for it, the provision of this good creates positive net benefits for this individual.

The question of the incidence of the net benefits of an existing set of regulations is a positive question (a matter of fact). Some regulations can indeed have differential incidence across regions (or groups) and that accurate knowledge about these differentials may be helpful to policy-makers who must weigh the gains to the winners against the losses to the losers and make an authorized choice on behalf of us all.

The problem of measurement is a compelling argument against disaggregation of net benefits to assess differences in regulatory incidence across regions or groups in society. Unfortunately, it will typically be a very compelling argument in the case of air quality regulations. It is likely to be technically infeasible to determine with sufficient precision the benefits and costs accruing exclusively to different regions or groups as a result of current or proposed regulations. Identifying the beneficiaries of improved air quality may be a reasonably tractable problem. If one can determine air quality in a designated region, with and without a set of air quality regulations, then the residents of that region will be the set of individuals that enjoys the human health benefits of the program. If the services of the affected ecosystems in the region also accrue only to these same people, then the benefits can be reasonably well demarcated.

However, as discussed in the preceding sections, the costs of improved air quality in this same region may be much more difficult to identify. Firms often believe that the cost of air quality improvements comes "out of their pockets." In reality, these costs are typically passed on, in whole or in part, to the consumers of that firm's outputs, and the rest is absorbed by the firm's investors. The incidence of increased regulatory costs, across consumers and investors, is determined by the elasticities of demand and supply in markets for this firm's output. Furthermore, there may be significant general equilibrium impacts on other markets, as any price changes are propagated through related markets. Only some of the consumers and investors that are ultimately affected by the regulations that produced the initial improvement in air quality will also be beneficiaries, living in the region where air quality improvements are felt. Tracing all of the eventual costs is a daunting task, since they are not delimited by the same boundaries as the physical air quality effects that determine benefits.

Thus, geographic regions or political jurisdictions are highly problematic as boundaries for net benefits disaggregation for the purpose of regulatory incidence analysis. If the program is national, it might be relatively easy to map regional emissions and health or ecological effects into regional benefits. However, some of the costs of the program borne by residents of the region will stem from compliance activities of firms in the region, but some of the other costs to the same residents will be derived from compliance activities of firms outside the region (to the extent that they are consumers of, or investors in, those outside firms).

The Council notes that any national-level net benefits analysis of the CAAA for the US is itself implicitly a regional disaggregation of the full global benefits and costs associated with this program. Since the relevant constituency for the net benefits analysis is US citizens, this geographical disaggregation is appropriate. The relative tractability of this choice of jurisdictional boundary is aided by the fact that international boundaries are much less permeable to trade and investment than are regional or state boundaries. Individual states within the US, for example, are highly open economies, between which trade is relatively unconstrained, and need not, therefore, be documented. The US as a whole is a much less open economy, and transactions across boundaries are much fewer and record-keeping is more extensive.

Achieving clean air imposes costs of varying sizes on different people, and corresponding benefits are rarely such that the result is a uniform distribution across the population of the net benefits of cleaner air. It is possible that net benefits in some areas, or for some groups, may even be negative. Such a finding would not condemn the CAAA, but it might point the way towards further fine-tuning of the methods of regulation. For example, there may be lower-cost ways of achieving the same degree of air-quality improvements (or ways to achieve greater improvements at the same cost) by allocating responsibility for emissions control more cost-effectively.

In sum, attempts at regional disaggregation of net benefits within the US are difficult because of the problems of tracking the diffusion of regulatory costs through the economy. The benefits and costs of implementing many programs also go beyond state, regional and national boundaries. As the disaggregation becomes finer, it is increasingly difficult to identify which benefits and costs are attributable exclusively to a particular region or group. The Council does recognize the value of information disaggregated at the state and regional levels to decision-makers who must justify programs at the state and regional levels. But misleading estimates of differential net benefits for different regions or groups could conceivably lead to worse policy choices than no information at all about the distribution of net benefits. The Council recommends that the EPA, for the most part, decline to disaggregate net benefits by region or by group. The appeal of such disaggregations should always be acknowledged, and a decision not to provide them should be justified by documentation of the difficulties in measuring or quantifying benefits and/or costs at the level of disaggregation desired. If the EPA elects to provide costs and benefits at regional levels in the Second Prospective Analysis, and especially if it provides estimates of net benefits at regional levels, it must include very clear explanations of the limitations of the disaggregation.

9.6. Geographic Disaggregations Proposed in the Draft Analytical Plan

The EPA requested that the Council consider three options for geographic disaggregation: a) regional-level costs/national-level benefits; b) regional-level costs and benefits; and c) state-level costs/state-level benefits. It is not entirely clear whether these pairs of disaggregation possibilities refer to the separate presentation of disaggregated benefits and disaggregated costs, or to the disaggregation of net benefits (benefits minus costs).

Any proposed geographic disaggregation needs to makes sense scientifically. The treatment of costs and benefits of national programs, even on a national scale, has some underlying assumptions that make the analysis somewhat artificial. Air quality in the US is influenced by policies and resulting emissions in Canada and Mexico. Indeed, studies are beginning to quantify the long-range transport of aerosols and gases from other continents to the US. The result of the long-range transport and transformation that is a fundamental characteristic of air quality assessment is that changes in air quality in a particular area are the result of emission changes occurring on local, state, regional, national and, to some extent, even international scales.

Option (b), regional disaggregation, makes the most sense in terms of geographical resolution along political or management divisions. In rare special cases where costs are borne by individuals and benefits accrue mostly to the same individuals, it may be almost possible to corral most of the relevant benefits and costs within some geographical jurisdictional boundary to permit reasonably accurate assessments of net benefits in that region. This might approximate the case for mobile-source controls on localized pollutants from automobiles. It will be much less appropriate for stationary source SO2 controls, where costs are borne by both investors and consumers and benefits accrue widely over the area downwind from each source.

For descriptive benefits-only disaggregation, common multi-state groupings may be the most defensible, but the groupings must be done carefully. The best approach would be to identify air quality control regions or programs that have come together to tackle the ozone/PM problem, or two major pollutants in the cost/benefit analysis [CONCRETE EXAMPLES, PLEASE]. One could identify at least the following regions: OTAG (Northwest/Mideast) [EXPLAIN A LITTLE MORE]; Southern California, and Atlanta or Houston, plus each suburb. [DO THESE SUBREGIONS ACCOUNT FOR THE MAJORITY OF BENEFITS?]

For benefits measures, the Council suggests that the most appropriate disaggregation, from a scientific perspective, would be the use of broad regional airsheds and clustering by areas with particularly high densities of monitoring. In many cases these areas are closely related to regional planning organizations. However, if one examines the density of air monitoring networks across the country, the western regional air partnership [IS THIS A FORMAL NAME?] can be further subdivided into the West Coast and "everything else." Perhaps, for the western states, disaggregation could follow census regions. [ORIGINAL REFERRED TO CENSUS "TRACTS". THESE WOULD BE WAY TOO SMALL. PLEASE CLARIFY INTENT, OVERALL.]

Sensible geographic disaggregation for benefits assessment for specific pollutants might identify regions which enclose both the major emission sources and the areas downwind of the major sources where the impact of emissions is likely to be felt. Of course, the impacted areas may be different for different pollutants. Ozone might be used to determine the impacted areas [FOR OZONE REGS, OR OTHERS TOO?]. Ozone is difficult to control, and it has a lifetime of one-to-two days in the troposphere. Its precursors can also travel long distances, especially at night, by means of nocturnal jet [DOES THIS NEED TO BE DEFINED?]. Accordingly, spatial disaggregation should be based on regions that cover the major emission sources and the ozone-impact areas several hundred kilometers downwind of the sources.

The Council emphasizes, however, that allowing impacted areas to dictate regional geographic partitions facilitates identification of the beneficiaries of air quality regulations and the extent of their gains. However, the costs may be borne by entirely different sets of people. Many of the investors and consumers of the affected firms will live outside the region thus identified. Elasticities of demand and supply in the markets for affected firms' outputs will dictate the extent to which cost increases due to regulation will be borne by each of these groups.

9.7. Benefit/Cost Ratios versus Net Benefits

The practice of assessing the social desirability of a policy by calculating a ratio of benefits to costs can be misleading. The benefits associated with some policies come in the form of reduced costs. And some of the costs of a policy may take the form of reduced benefits. This symmetry between costs and benefits can confuse the calculation of a benefit-cost ratio, but is innocuous when using a net benefits metric, where the criterion is benefits minus costs. Many economists would prefer to do away with benefit/cost ratios altogether, since these also obscure the magnitudes of benefits and costs. Two policies having the same benefit/cost ratio can have very different magnitudes of their net benefits.

The Council also has some doubts about whether benefit-cost ratios should be considered in reporting uncertainties in benefits or costs. Combining the central value with a low or a high may give a misleading perception of the relative uncertainties.

In conclusion, net benefits are better for presentation than the ratios. Also, given the different types of uncertainties in costs and benefits, it is best to present total costs, total benefits, and net benefits together to give a sense of the scale for each.

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APPENDIX A

RESPONSES TO EPA'S KEY SPECIFIC QUESTIONS NOT ADDRESSED IN THE MAIN TEXT

Question 6. Does the Council have a preference for an appropriate source of state-level economic growth-rate estimates to be applied in the emissions projections, either the 1995 vintage BEA estimates or the more recent eGAS system results? The EGAS system is described in detail in the EGAS Reference Manual, which can be downloaded in PDF format at the following addres: www.epa.gov/ttnchie1/emch/projection/egas40/ref_man_4.pdf.

There are likely to be 50 different models generating this information. Each state will have its own state or regional demographic and economic forecasting model, maintained to serve government planning. These models are likely to be of highly variable quality, sophistication, and accessibility. They are unlikely to be conformable. In addition, there are several prominent commercial demographic and economic forecasting models. Their current regional forecasts are available only to paid subscribers. There may also be mixed marketing strategies, where basic forecasts are made available to governments, but more specific sectoral forecasts are available, at a price, to individual firms. For example, the UCLA Anderson Forecast (http://www.anderson.ucla.edu/research/forecast/index.htm). Current quarterly forecasts for California are available at $350.00. Rutgers University Center for Urban Policy Research (CUPR) established the Rutgers Economic Advisory Service (R/ECON™) in 1992 (see http://policy.rutgers.edu/cupr/recon.htm). It provides economic forecasts for the state of New Jersey.

The Council knows of no national-level economic forecasting model that will provide reliable state-level forecasts for all of the variables that would be necessary for state-level disaggregate forecasts of the benefits and costs of air quality regulations.

Question 9. "The analytical plan proposes using REMSAD Version 6 for PM and ozone modeling. An older version of REMSAD, Version 4.1, is also available. Version 6 has been updated to address the key peer review comments on Version 4.1, is also available. Version 6 had been updated to address the key peer review comments on Version 4.1: however, it is currently undergoing testing and evaluation, and has not yet been employed in official EPA regulatory analyses. Does the Council have a preference for one of these for one of these versions?"

These questions really cannot be answered at this time because Version 6 (or 7) of REMSAD is still under development and scheduled for evaluation. In principle, if all the recommendations of the REMSAD review (Seigneur et al., 1999) are incorporated in the upcoming version(s), and if these versions "pass" reasonable, but well defined performance evaluation tests[1] , it/they should be used for nationwide PM modeling. REMSAD is anticipated to perform acceptably in predicting sulfate levels. However, the issues of nitrates and secondary organics are quite open. With respect to ozone, the Seigneur et al. 1999 review states clearly that "REMSAD is not intended for application to O3 air quality" (page 2-1).

Question 10: Does the Council support the use of REMSAD for ozone modeling nationwide, contingent on the results of a model performance comparison with UAM-V?

The answer to this question can only be "contingent on the results of a model performance comparison with UAM-V" as well as thorough diagnostic performance evaluation by region/airshed with observations.

Question 11: Does the Council support the use of REMSAD for modeling mercury transport and deposition?

[1]Of course, adequate, species-resolved, data sets for such an evaluation exist only from 1999 forward; the quality of the 1999 inventory (expected to be finalized by October 2001) is also expected to be superior to those up to now available for modeling. Since post-1999 data do not seem to be expected to be incorporated in the proposed study, it should be strongly recommended that the evaluation of REMSAD for PM should include cross-model comparisons with predictions from CMAQ, MAQSIP/MAQSIP-UDAERO, etc.

Mercury is the only HAP for which this question is asked, although REMSAD is designed to be applied to a number of other HAPs. It has been stated and summarized in the material provided by EPA and its contractors that the upcoming versions of REMSAD will incorporate up-to-date descriptions of mercury atmospheric chemistry/physics, as per the specific recommendations of the Seigneur et al. (1999) review.

However, the issue that still has to be addressed is whether the errors associated with the coarse spatial resolution of the REMSAD application would be acceptable. According to existing inventories, a majority of mercury emissions comes from large point sources such as coal-fired power plants. Therefore mercury chemistry for the initial hours after release takes place in highly concentrated plumes. This means that reaction/conversion rates can be significantly different than when calculated with concentrations artificially diluted over an area of 36x36km2. It is necessary to perform a thorough evaluation of this issue.

It would be indeed be great if REMSAD can reproduce ozone patterns (and responses to emission changes) with sufficient accuracy/precision for the needs of the current 812 Analysis. However, this has to be formally established, and it is not a trivial exercise. REMSAD was never intended for "application to O3 air quality". In fact, the earlier versions were using observed or modeled ozone values as inputs. Since the introduction of the microCB4 mechanism, REMSAD has been able calculate such values internally, but the objective was not to use them to assess ozone control strategies but only to provide approximate information needed for the chemistry of other species. The REMSAD User's Guide (June 1998) explicitly states (page 2-3): "The intent of the microCB4 mechanism is not to predict ozone levels with the precision usually sought in air quality models designed to address the ozone issue per se, but rather to provide a physically faithful representation of the linkages between emissions of ozone and PM precursors; the oxidizing capacity of the troposphere…". Seigneur et al. (1999) state (page 2-9) regarding the comparison of microCB4 to CB4 results, in a "stand-alone mode" that "such results are encouraging but additional tests are needed…".

Recent and on-going studies on ozone and PM use UAM-V and REMSAD in complementary fashion to address individual model limitations in both the chemistry and transport descriptions. For example, in the REMSAD Modeling Protocol (March 9, 2001) of the on-going WRAP Regional Modeling Center study it is stated (page 4) that "while the (REMSAD) grid structure is appropriate for regional- or continental- scale particulate air quality models, the vertical grid structure is likely too coarse for accurate treatment of nighttime scavenging of O3 by surface NO emissions." This finding is in agreement with the assessment of Seigneur et al. (1999).

Clearly, the ability of REMSAD to characterize ozone dynamics with sufficient pre-defined accuracy and precision is still to be assessed and established.